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ART. I.—*Contributions to Meteorology: being results derived from an examination of the observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Tenth paper. With Plates I and II.

[Read before the National Academy of Sciences, New York, Nov. 6, 1878.]

Storms of the Atlantic Ocean.

IN a former paper, I have noticed some storms which could be traced across the Atlantic Ocean by means of the Paris storm charts from June, 1864, to December, 1865, and Hoffmeyer's charts from December, 1873, to August, 1874. Having received a copy of Hoffmeyer's charts complete to November, 1875, I have undertaken a more careful examination of Atlantic storms. I first provided myself with a large number of blank maps of the Atlantic Ocean, upon precisely the same scale as Hoffmeyer's charts, so that observations could be readily transferred from Hoffmeyer's charts to my own. I then made a careful examination of all the charts in succession. For the first three months (December, 1873, to February, 1874), the isobars are not drawn beyond the meridian of 30° west of Paris, so that these charts were not available for this investigation. For the month of March, 1874, I selected the first chart, which showed an isobar as low as 750 millimeters (29·5 inches), near the coast of the United States, and marked upon one of my maps the position of the center of the lowest isobar. If the same low area could be identified on the chart of the following day, I marked upon my map the position of the center of the lowest isobar for that date, and I did the same for each following day as long as the low area could be identified. The

Storms of the Atlantic Ocean.

No.	Date.	First appearance.			Long. 60°.		Long. 30°.		Long. 0°.		From 60° to 0°.		On English Coast.	
		Lat.	Long.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Days.	Aver. velocity	Highest wind.	Direc'n of wind.
	1874.													
1	Mar. 4	46°5	75°5	745										
2	8	47·0	77·1	750	48°1	745	60°7	740	68°7	735	2·8	36·4	4	S.W.
3	20	47·0	61·3	740	49·2	740	65·0	730	72·5	745	4·0	24·8	4	W.N.W.
4	23	53·5	55·0	740	51·4	740	63·2	735	61·8	750	14·6	6·5	3	S.W.
5	April 3	48·6	70·6	750	52·3	750	62·6	745	48·5	740	9·2	12·0	5	W.N.W.
6	12	46·4	63·5	750										
7	15	51·8	74·0	750	50·0	750	60·2	745	67·7	745	6·1	15·8	4	S.
8	21	47·0	75·0	750										
9	26	41·5	72·2	745	44·5	740								
10	30	46·5	71·3	740	44·0	750								
11	May 26	47·0	76·7	750	55·0	750	59·4	745	66·4	755	6·7	12·8	3	W.
12	June 1	43·0	69·3	745										
13	8	48·0	72·0	750	44·5	750								
14	13	50·5	75·0	750	47·8	755								
15	18	44·2	71·8	750										
16	23	52·5	70·0	750	49·1	750								
17	29	45·0	80·0	750										
18	July 8	47·8	71·8	750										
19	16	45·6	71·8	750										
20	Aug. 1	47·5	75·5	745										
21	Sep. 11	49·5	56·4	750										
22	30	45·6	71·8	740										
23	Oct. 11	51·5	71·4	745	59·6	750	61·9	740	68·5	740	7·8	9·6	5	W.
24	18	51·9	68·0	745	54·5	750	64·6	730	69·6	730	5·7	13·8	4	S.W.
25	28	37·0	62·0	750	38·2	750	38·2	755						
26	30	51·3	71·0	750	54·4	755	64·0	740	68·0	740	3·3	22·6	3	S.W.
27	Nov 10	46·6	56·0	745	50·8	745	69 0	745	62·0	740	5·1	16·1	4	N.W.
28	21	44·2	67·8	745	43·3	750								
29	24	48·0	70·0	735										
30	29	46·0	72·7	750										
31	Dec. 9	52·7	56·0	750	49·8	750								
32	15	50·0	59·0	750	49·3	750	62·6	745	64·6	755	9·7	10·2	5	S.W.
33	21	40·0	65·5	750	39·2	755								
34	25	47·4	57·7	740	47·7	740	59·0	735	59·3	740	9·3	11·1	4	S.W.
	1875.													
35	Jan. 3	46·8	60 8	735	47·4	735	59·5	735	61·4	740	13·3	7·7	3	S.W.
36	8	43·5	65·0	740										
37	10	45·4	58·0	750	45·8	750	*	*	*	*	6·0	17·6	3	S.W.
38	14	43·4	66·0	750	47·6	745	58·3	740	61·5	735	5·0	21·1	4	S.W.
39	23	42 8	62·0	750	43·2	750	59·5	740	68·6	740	9·0	12·6	3	S.
40	25	44·5	68·7	750	49·7	745	†	†	†	†	6·5	14·9	3	S.
41	30	43·0	63·6	750	43·0	750	56·8	745	68·5	750	16·3	6·9	3	S.W.
42	Feb. 1	41·5	63·0	745	44·7	745	†	†	†	†	14·1	7·7	3	S.W.
43	8	40·5	64·5	740	43·6	745	†	†	†	†	7·0	16·0	3	S.W.
44	12	47·6	66·3	740	59·0	740								
45	20	45·0	84·3	750										
46	26	46·5	64·0	730	51·0	735	47·3	725	73·0	740	10·5	9·1	5	W.
47	Mar. 7	39·8	57·2	750	41·5	750								
48	8	40·5	67·0	745	42·3	745	†	†	†	†				
49	17	46·0	68·0	745	53·2	740	63·2	720	67·6	745	9·3	9·5	4	W.
50	25	42·4	68·4	745	60·4	745	64·8	755	63·7	740	7·7	10·1	4	W.

Storms of the Atlantic Ocean.

No.	Date.	First appearance.			Long. 60°.		Long. 30°.		Long. 0°.		From 60° to 0°.		On English Coast.	
		Lat.	Long.	Lowest Barbar.	Lat.	Lowest Barbar.	Lat.	Lowest Barbar.	Lat.	Lowest Barbar.	Days.	Aver. velocity	Highest wind.	Direct'n of wind.
	1875.													
51	April 6	38°0	53°0	750	40°5	750	45°2	740	48°5	755	16·4	7·4	3	E.
52	14	41·5	72·3	750	40·6	750	†	†	†	†	7·4	16·3	3	E.
53	16	45·0	77·3	750	45·3	745	50·2	740	72·8	745	14·1	7·7	3	S.
54	25	39·7	60·0	750	39·7	750	†	†	†	†	9·8	12·6	3	S.
55	30	46·5	77·2	745	47·3	750	47·0	750						
56	May 2	50·0	78·6	740	53·0	750	62·4	745	†	†	†	†		
57	5	42·5	57·5	750	†	†	†	†						
58	7	41·4	67·5	750	41·0	750	54·0	745	67·7	750	7·0	17·0	3	W.
59	12	45·0	83·5	750										
60	Jun. 17	39·9	58·4	750	40·0	750								
61	19	43·2	68·8	745	53·8	745	61·4	745						
62	28	48·5	73·5	750	53·8	750	62·3	750						
63	July 17	43·3	66·6	750	44·3	750								
64	25	44·8	59·7	750	44·7	750								
65	30	40·4	67·7	750										
66	Sept. 4	47·4	77·5	750	62·0	750								
67	17	42·5	73·0	750	46·3	745	44·6	735	58·7	730	8·8	12·0	5	W.
68	26	48·3	60·0	750	48·3	750	65·0	740						
69	Oct. 2	50·0	63·0	750	51·8	750	59·6	740	66·7	735	3·2	28·7	3	W.
70	16	47·6	66·2	750	56·8	745	53·4	735	47·8	755	9·9	10·5	4	E. to W.
71	21	44·2	55·7	745	42·7	750	†	†	†	†	7·0	16·9	4	E. to W.
72	25	40·0	64·4	750	40·0	745	49·6	745	64·4	745	10·2	11·7	3	W.
73	28	48·6	63·5	750	48·3	750	†	†	†	†	7·2	13·9	3	W.
74	31	43·7	72·0	740	45·3	740	52·4	750	52·0	725	8·9	12·4	5	N.W.
75	Nov 11	43·5	69·6	735	45·9	740	53·8	745	56·8	755	6·0	17·9	4	W.
76	17	46·6	64·7	725	47·5	740								
77	29	47·3	70·0	750	48·8	740								
	Means			746	49·6	746	58·0	74[illegible]	63·3	743	8·5	14·0		

* This low area appeared to coalesce with No. 35.

† This low area appeared to coalesce with the low next preceding.

points thus determined were connected by straight lines, and the probable track of the low area was thus obtained. The same method was pursued with each of the charts to November 30, 1875. I thus obtained seventy-seven cases of low areas near the coast of the United States, and was able to follow thirty-six of them with considerable confidence entirely across the Atlantic Ocean; but eight of these storms became merged in other storms before reaching the European coast, leaving only twenty-eight different low areas which reached the coast of Europe. The preceding table exhibits the most important particulars relating to these seventy-seven cases. Column 1st contains the number for reference; column 2d shows the date of the chart upon which a low area was first found near the coast of the United States; column 3d shows the latitude, and

column 4th the longitude of the center of the lowest isobar for the date mentioned in column 2d, and column 5th shows the amount of the lowest isobar. As the isobars are drawn at intervals of five millimeters, it is probable that at the center of the low area the pressure was frequently as low as 745 m. (29·3 inches), and sometimes lower. Column 6th shows the latitude in which the central path of the low area crossed the meridian of 60° W. from Paris, and column 7th shows the lowest isobar for that position; column 8th shows the latitude in which the central path crossed the meridian of 30° W. of Paris, and column 9th shows the lowest isobar for that position; column 10th shows the latitude in which the central path crossed the meridian of Paris, and column 11th shows the lowest isobar in that position; column 12th shows the number of days required for the low center to travel from the meridian of 60° to that of Paris; and column 13th shows the average velocity of the center in its course between these two meridians. This average is obtained by supposing the center to have followed the arc of a great circle, and takes no account of the actual irregularities of its course. Column 14th shows the highest wind reported on the English coast at the time the low center was nearest. These winds are estimated upon a scale from 1 to 6, where 1 denotes a light breeze; 2 a fresh breeze; 3 very fresh; 4 a hard wind; 5 a gale, and 6 denotes a hurricane. The velocities given in column 14th are the highest velocities reported anywhere near the coast of England, but do not include Scotland. If Scotland had been included, the velocities in some cases would have been greater. Column 15th shows the direction of the wind corresponding to the velocity in column 14th. Sometimes at several stations the same velocity was reported, but with different directions. The direction given in column 15th is the one which occurs most frequently for the given date and velocity.

We see from this table that in one year there are on an average only eighteen different storms which can be traced by means of Hoffmeyer's charts from the coast of the United States across the Atlantic. If for each day we had two good charts, instead of only one, it is probable that a few more storms might be identified in their progress across the ocean, but it is doubtful whether the number would be greatly increased. Nearly all of these storms pursued a course north of east, and passed considerably to the north of Scotland. In only four of the cases did the low center cross the meridian of Paris in a latitude as low as the northern boundary of England. The average track of the thirty-six low centers which are traced across the ocean, is shown by the means at the bottom of the table, where it is seen that the meridians of 60°, 30° and 0°,

were crossed in the latitudes 49°·6, 58°·0 and 63°·3. Since the storm centers generally passed 800 miles north of London, most of them did not exhibit much violence on the English coast. In half of the cases, the highest velocity reported was 3, denoting a very fresh breeze, and in only six of the cases was the velocity at any station on the English coast as high as 5, denoting a gale.

We may hence conclude that when a center of low pressure (below 29·5 inches) leaves the coast of the United States, the probability that it will pass over any part of England is only one in nine; the probability that it will give rise to a gale anywhere near the English coast is only one in six; and the probability that it will give rise to a very fresh breeze is one in two.

One of the most noticeable circumstances connected with Atlantic storms is their slow rate of progress. This is due partly to the erratic course of the center of the low area, and partly to the frequent blending of two low areas into one, whence it generally results that the most eastern center appears to be pushed backward toward the west. In my eighth paper I have described a remarkable example of this kind of movement. In like manner the storms numbered 35, 39, 41, 51, 53, 70 and 72 of the preceding table appeared to be pushed westward by blending with storms of a subsequent date. Aside from this cause of detention, there seems in the Atlantic Ocean to be a special cause which frequently holds storms nearly stationary in position from day to day, and this cause is probably the abundance of warm vapor rising from the Gulf Stream, in close proximity to the cold dry air from the neighboring coast of North America. Hence we see that when American storms are predicted to appear upon the European coast, and it is assumed that they will cross the ocean at the same rate as they have crossed the United States, such predictions will seldom be verified.

It will also be noticed that the storms which cross the Atlantic, generally increase in intensity after leaving the American coast; the average depression of the barometer shown in the preceding table being 6 millimeters (0·24 inch) greater in long. 30° than in long. 60°.

Origin of the storms here traced.—Two of the storms enumerated in the preceding table and which have been traced across the Atlantic (Nos. 51 and 70), appear to have originated over the Atlantic Ocean; five of them (Nos. 46, 52, 54, 73 and 75), appear to have originated in Texas or its vicinity; four of them (Nos. 67, 69, 71 and 74), appeared to originate in the middle latitudes, but considerably east of the Rocky Mountains; about half of the whole number appear to have originated in the neighborhood of the Rocky Mountains; that is, it is diffi-

cult to trace them satisfactorily further west; but four of the number can be distinctly traced to the Pacific coast, viz: two of them (Nos. 26 and 41) to California, and two of them (Nos. 39 and 40) to Oregon. The course of No. 39 is represented on Plate I. At 7.35 A. M., January 19th, the barometer at Portland, Oregon, stood at 29·34, and at 4.35 P. M. at 29·22, a depression which has seldom been observed at that place. This low area traveled eastward across the United States with diminishing intensity. On the morning of the 20th, the greatest depression was at Bismark, 29·48; on the morning of the 21st, at Keokuk, 29·75; on the 22d, at Alpena, 29·74; on the 23d, at Sydney, 29·54, and during the next two days the depression still further increased. Another low area had now arrived at Nova Scotia, and on the 26th had approached so near the former that the two seemed inclined to coalesce. On the two following days this tendency became more decided, and on the 29th both were united in one great depression, the pressure near the center being 28·94. This low area advanced toward the northeast without any perceptible diminution of intensity; but when it had nearly reached the North Cape, its course was turned to the southeast. The center of this low area has thus been traced through about 150° of longitude, and considering that the depression was unusually great when first observed in Oregon, it seems safe to conclude that this low area preserved its identity through more than 180° of longitude. It will be seen, however, that this storm of January 19th to February 3d, 1875, was an unusual case. The changes of the barometric depressions are so frequent that a low area can seldom be identified in its progress from the Pacific Ocean to Eastern Europe.

West India Cyclones.—During the period embraced by Hoffmeyer's maps, there occurred several cyclones which originated in or near the Gulf of Mexico. The following cases are noted on the maps of the United States Signal Service:

1.	1874, Sept. 5– 7.	4.	1875, Sept. 14–19.
2.	" Sept. 9–11.	5.	" Oct. 13–16.
3.	" Sept. 27–30.	6.	" Nov. 8–11.

No. 1 apparently moved northward and was merged in a larger depression previously existing near South Greenland. No. 2 cannot be certainly identified on the map of September 12th. No. 3 apparently moved northward over Labrador. No. 4 (the great Indianola hurricane) appeared to merge in a greater depression previously existing near Newfoundland, without producing any sensible modification in it. No. 5 can be traced across the Atlantic, but during its progress it blended with one or two other depressions. No. 6 can be traced across the Atlantic, and throughout the entire passage preserved its identity pretty

distinctly. Thus we see that of the six cyclones here mentioned, only two can be traced across the Atlantic, and only one of them escaped blending with another depression. These cases (although few in number) suggest the conclusion that the West India cyclones, however violent they may be within the tropics, when they reach the middle latitudes, expand in area and lose much of their violence, and after a few days are usually merged in some of the larger depressions which generally prevail in some part of the North Atlantic Ocean.

Fluctuations of the barometer on Mt. Washington and Pike's Peak.

The Annual Report of the United States Chief Signal Officer for 1873 contains a series of hourly observations of the barometer on the summit of Mt. Washington (elevation 6,285 feet), and also at the base of the mountain (elevation 2,898 feet) during May and June, 1873. I have projected all these observations in curve lines and find a general correspondence between the fluctuations of the barometer at the two stations, with some decided differences, among which the most noticeable is that the maxima and minima of pressure generally occur earlier at the base of the mountain than they do at the summit. The following table shows the principal maxima and minima for the months of May and June, the barometric readings being corrected for temperature and instrumental error only.

Barometer at base and summit of Mt. Washington.

	Date.	Base.		Summit.		Diff.
Min.	May 3	12 M.	26·820	2 P.M.	23·390	+2h.
Max.	8	7 A.M.	27·547	11 A.M.	24·114	+4
Min.	13	2 P.M.	26·654	6 P.M.	23·147	+4
Max.	21	8 A.M.	27·480	9 A.M.	24·055	+1
Min.	24	1 P.M.	26·822	5 P.M.	23·422	+4
Max.	26	8 A.M.	27·346	9 A.M.	24·029	+1
Min.	28	4 P.M.	26·988	9 P.M.	23·631	+5
Max.	29	10 A.M.	27·187	5 P.M.	23·839	+7
Min.	30	12 P.M.	27·114	5 A.M.	23·607	+5
Max.	31	9 A.M.	27·500	4 P.M.	24·021	+7
Min.	June 5	2 A.M.	26·756	5 A.M.	23·406	+3
Max.	8	6 P.M.	27·388	6 P.M.	24·040	0
	9	5 A.M.	27·393	11 A.M.	24·012	+6
Min.	11	6 A.M.	27·007	9 A.M.	23·670	+3
Max.	13	4 A.M.	27·430	10 A.M.	24·043	+6
Min.	17	2 A.M.	26·952	4 A.M.	23·540	+2
Max.	18	8 A.M.	27·138	12 M.	23·748	+4
Min.	20	2 A.M.	26·788	4 A.M.	23·468	+2
Max.	25	10 A.M.	27·582	12 M.	24·270	+2
Min.	28	4 A.M.	26·983	5 P.M.	23·708	+13

Several of these maxima and minima are represented on Plate II. The upper curve represents the barometric fluctuations on

the summit of the mountain from May 12, 2 P. M., to May 16, 2 P. M., the interval between the horizontal lines representing a difference of one-fiftieth inch pressure, and the interval between the vertical lines representing two hours of time. The second curve represents the barometric fluctuations at the base of the mountain for the same dates. The third and fourth curves represent the fluctuations from May 22, 8 P. M., to May 26, 8 P. M.; and the fifth and sixth curves represent the fluctuations from May 28, 10 A. M., to June 1, 10 A. M. The minimum of May 13th is pretty sharply defined, and occurred on the summit four hours later than at the base. On the morning of May 15th occurred another minimum, which at the summit was sharply defined, but at the base was inconsiderable. The minimum of May 24th was pretty sharply defined at both stations, and the same is true of the maximum May 26th. From May 28th to June 1st occurred two minima and two maxima which are not very sharply defined, but the critical points at the summit evidently lag behind the corresponding points at the base. The maximum of June 8th continued for twenty-four hours with but little change, and the highest reading occurred at the summit of the mountain earlier than at the base, which may be regarded as an exception to the general rule. If, however, we compare the corresponding undulations of the two curves, I think it will appear that the first maximum occurred at both stations at about the same instant, and the second maximum occurred six hours earliest at the base. The decided fall of the barometer began six hours earlier at the base than at the summit. The minimum of June 28th continued for eighteen hours without much change, but the absolute minimum occurred thirteen hours earlier at the base than at the summit.

These observations appear to me to prove that the maxima and minima of the barometer do not generally occur simultaneously at the top and bottom of Mt. Washington, but on an average occur more than three hours later at the summit than at the base, showing an average retardation of one hour for each 900 feet of elevation.

In order to test this result by independent observations, I compared the observations made on the summit of Mt. Washington with those made at Burlington, Vt., and Portland, Me., from September, 1872, to January, 1875. Burlington and Portland are distant from each other about 150 miles, and Mt. Washington is about midway between them, and we might expect that the barometric minima at Mt. Washington would occur at dates intermediate between those at Burlington and Portland. I therefore selected all those cases in which the barometer at Portland fell as low as 29·6 inches, and deter-

mined the times of barometric minima at these three stations. The result is shown in the following table, where the numeral 1 following a date denotes the 7.35 A. M. observation; 2 denotes the 4.35 P. M. observation; and 3 denotes the 11 P. M. observation. When the pressure at two successive observations was sensibly the same, I have taken the intermediate date as being the true time of minimum. The fifth column shows the difference between the date of minimum on Mt. Washington and the half sum of the dates at Burlington and Portland expressed in units of eight hours.

Barometric minima at Burlington, Vt., Portland, Me., and Mt. Washington, N. H.

	Burl'n.	Portl'd.	Mt. W.	Diff.		Burl'n.	Portl'd.	Mt. W.	Diff.
1872.	d.	d.	d.		1873.	d.	d.	d.	
Oct.	14.1½	14.1½	14.2	+0·5	Dec.	26.3	26.3	26.3	0·0
	27.1	27.1	27.1	0·0		28.1	28.1	28.2	+1·0
Nov.	7.1	7.2	7.3	+1·5	1874.				
	12.2	12.3	12.3	+0·5	Jan.	8.2	8.2	8.2½	+0·5
	14.3	14.3½	15.1	+0·7		10.1	10.2	10.2	+0·5
	30.1	30.1	30.1	0·0		15.2	15.2½	16.1	+1·7
Dec.	2.3	3.1	3.1	+0·5		23.1	23.2	23.2	+0·5
	9.1	9.3	10.1	+2·0		28.1	28.2	28.3	+1·5
	27.2	27.2	28.1	+2·0	Feb.	10.2½	10.3	11.1½	+1·7
1873.						13.3	14.1	14.1	+0·5
Jan.	3.3	3.3	4.1	+1·0		16.2	16.3	17.1	+1·5
	5.3	5.3	6.1	+1·0	March	4.1	4.2	4.2	+0·5
	21.3	22.1	22.1	+0·5		9.1	10.1½	10.1	+1·2
	27.2	27.3	27.3	+0·5		19.2	19.3	20.1½	+2·0
Feb.	4.2	4.2	4.2½	+0·2		22.3	23.1	23.1	+0·5
	8.1	8.1	8.2	+1·0		26.2	26.3	26.3	+0·5
	21.2½	21.3	22.2	+1·2	April	3.1	3.2	3.2	+0·5
March	3.2	3.2	3.3	+1·0		15.2	15.2	16.1	+2·0
	8.2½	9.1	9.1	+0·7		21.1	21.1	21.1½	+0·5
	16.1	16.1½	16.3	+1·7		26.1	26.1	26.1	0·0
	21.1½	21.1½	21.2½	+1·0		30.2	30.1	30.2	+0·5
	23.2	23.3	24.1	+1·5	May	5.2½	5.2	5.3½	+1·2
	26.2	26.3	27.1	+1·5		25.2½	25.3	25.3½	+0·7
	29.3	30.1	30.1	+0·5		31.2½	31.2½	32.1	+1·5
	31.1	31.2	31.2	+0·5	June	7.3½	8.1	8.2	+1·2
April	14.2	14.2	14.1	−1·0		17.2½	17.3½	17.3½	+0·5
	19.1½	19.2	19.3	+1·2		23.2	23.3	24.1	+1·5
	25.3½	26.1½	26.1	0·0		28.2	28.2	28.3	+1·0
May	13.1	13.2	13.2	+0·5	Aug.	1.2	1.2	1.2	0·0
	24.1½	24.2	24.2	+0·2	Sept.	30.1	30.1	30.2	+1·0
June	4.2½	4.2½	4.3½	+1·0	Oct.	2.2	2.2	2.3	+1·0
	19.3	20.2	20.2	+1·0		10.2½	10.3	11.1	+1·2
Sept.	1.2	1.2	2.1	+2·0		17.3½	18.2	18.3½	+2·2
Oct.	7.1	7.1	7.1	0·0	Nov.	10.3½	11.1½	11.3	+2·0
	12.1	12.2	12.3	+1·5		20.3	20.3	21.1	+1·0
	27.1	27.2	27.2	+0·5		23.3	23.3	23.3½	+0·5
Nov.	8.2	8.2	8.3	+1 0		29.1½	29.1½	29.2	+0·5
	12.3	12.3	13.1½	+1·5	Dec.	17.2	17.3	18.1	+1·5
	18.2	18.2	18.2	0·0		24.1½	24.2	24.2	+0·2
Dec.	4.1	4.2	4.2½	+1·0	1875.				
	13.2	13.3	13.3	+0·5	Jan.	2.2	2.2	2.3	+1·0

It will be seen that in one instance the minimum at Mt. Washington occurred earlier than it did at Burlington or Portland; in eight cases the minima occurred simultaneously; in seventy cases the minimum on Mt. Washington occurred later than the half sum of the dates at Burlington and Portland, the average difference being 0·88, or seven hours. The height of Mt. Washington above Burlington and Portland is 6,148 feet, showing an average retardation of one hour for an elevation of 870 feet.

I next compared the observations made at the summit of Mt. Mitchell in North Carolina (elevation 6,691 feet) with those made at the base of the mountain (elevation 2,560 feet) from August 6th to September 5th, 1873, published in the Report of the United States Chief Signal Officer for 1873, but the fluctuations of the barometer were too small to yield satisfactory results. The following are the most noticeable coincidences of minimum pressure:

	Base.	Summit.	Difference.
1873. Aug. 13	3 P.M.	4 P.M.	+1 hour.
15	2 A.M.	5 A.M.	+3 hours.
25	5 P.M.	7 P.M.	+2
27	2 A.M.	4 A.M.	+2
Sept. 4	3 P.M.	7 P.M.	+4
5	3 P.M.	6 P.M.	+3

These results indicate an average retardation of one hour for an elevation of 1,600 feet, but the fluctuations are so small that no great importance can be attached to them except as they are taken in connection with other observations.

I next compared the observations made on Pike's Peak (elevation 13,960 feet) with those made at Colorado Springs, the base of the mountain (elevation 5,850 feet), a copy of which observations I have received in manuscript through the kindness of General Myer. When the observations at these two stations are projected in curves, the differences between the two curves are seen to be considerable, but there is a large number of cases in which the resemblance is very decided. The following table contains those cases in which the dates of maximum and minimum pressure are most sharply defined. There are many other cases in which the general resemblance of the curves is very decided, but the change of curvature is too gradual to admit of a satisfactory comparison of the instants of maximum or minimum pressure. The table shows the date (hour and minute) of several maxima and minima both at Colorado Springs and Pike's Peak, and the last column shows the difference between the dates of the critical points at the two stations.

Barometer at Colorado Springs and Pike's Peak.

No.		Date.	Colorado Springs.		Pike's Peak.		Diff.
			h. m.	barom.	h. m.	barom.	h. m.
1	Max.	1873. Nov. 16	10.25 A.M.	30·15	4.25 P.M.	30·12	+ 6.10
2	Min.	22	7.35 A.M.	29·69	7.35 A.M.	29·64	0.00
3	Min.	Dec. 2	3.52 P.M.	29·48	3. 7.35 A.M.	29·18	+15.43
4	Min.	7	4.35 P.M.	29·58	7.47 P.M.	29·47	+ 3.12
5	Min.	11	4.35 P.M.	29·60	4.35 P.M.	29·48	0.00
6	Max.	13	8.13 A.M.	30·27	7.47 P.M.	30·18	+11.34
7	Max.	24	8.13 A.M.	30·27	11.00 P.M.	30·12	+14.47
8	Min.	25	11.00 P.M.	29·80	26. 7.35 A.M.	29·75	+ 8.35
9	Min.	1874. Jan. 3	7.35 A.M.	29·28	4.35 P.M.	29·32	+ 9.00
10	Max.	6	12.00 M.	30·17	7.47 P.M.	30·03	+ 7.47
11	Min.	26	4.35 P.M.	29·71	27. 7.35 A.M.	29·65	+15.00
12	Max.	28	8.13 A.M.	30·19	11.00 P.M.	30·07	+14.47
13	Max.	Feb. 8	12.00 M.	30·12	9. 7.35 A.M.	29·93	+19.35
14	Min.	12	10.25 A.M.	29·31	4.35 P.M.	29·20	+ 6.10
15	Max.	19	11.00 P.M.	29·81	11.00 P.M.	29·64	0.00
16	Min.	March 5	11.00 P.M.	29·43	4.35 P.M.	29·36	— 6.25
17	Min.	30	4.13 P.M.	29·65	4.35 P.M.	29·58	+ 0.22
18	Max.	April 2	8.52 A.M.	30·19	4.35 P.M.	29·95	+ 7.43
19	Min.	4	4.13 P.M.	29·63	4.35 P.M.	29·60	+ 0.22
20	Min.	May 1	4.35 P.M.	29·50	2. 7.35 A.M.	29·50	+15.00
21	Min.	9	3.52 P.M.	29·39	4.35 P.M.	29·46	+ 0.43
22	Max.	Oct. 21	11.00 P.M.	30·28	22. 12.00 M.	30·27	+13.00
23	Min.	24	7.35 A.M.	29·64	7.35 A.M.	29·63	0.00
24	Max.	26	12.00 M.	30·21	4.35 P.M.	30·11	+ 4.35
25	Min.	28	7.35 A.M.	29·59	3.17 A.M.	29·63	— 4.18
26	Max.	30	11.00 P.M.	30·31	11.00 P.M.	29·98	0.00
27	Max.	Nov. 12	12.00 M.	30·16	4.35 P.M.	30·06	+ 4.35
28	Min.	22	7.35 A.M.	29·32	7.35 A.M.	29·37	0.00
29	Max.	25	1.25 A.M.	29·98	7.35 A.M.	29·95	+ 6.10
30	Min.	Dec. 15	4.35 P.M.	29·58	7.47 P.M.	29·56	+ 3.12
31	Max.	23	11.00 P.M.	30·08	11.00 P.M.	29·79	0.00
32	Max.	1875. Jan. 21	4.35 P.M.	30·03	11.00 P.M.	29·76	+ 6.25
33	Min.	22	11.00 P.M.	29·75	23. 7.35 A.M.	29·54	+ 8.35

In a majority of the cases, the critical points occur several hours later on Pike's Peak than at Colorado Springs. In ten of the cases the difference was less than one hour, and in two cases the minimum appeared to occur earlier at the summit than at the base of the mountain. These anomalies are, however, more apparent than real. In No. 16 the barometer at Pike's Peak was lowest at 4.35 P. M., but at 7.35 A. M. of the next day it had risen only 0·02 inch. In No. 25, at the time of the minimum at Colorado Springs, the barometer at Pike's Peak had not yet begun to rise, so that we may claim that in both of these cases the minima occurred sensibly at the same instant at both stations. The average retardation indicated by all the cases in the table is $5^h\ 50^m$, or one hour for an elevation of 1,380 feet.

The number of cases here examined appears to be sufficient to warrant the following conclusions: that over the United States, both the maxima and minima of atmospheric pressure

generally occur first near the surface of the earth, and they occur later as we rise above the surface, the retardation amounting to one hour for an elevation of from 900 to 1,300 feet.

Since the changes in the pressure of the air generally begin at the surface of the earth, it might be presumed that the changes in the direction of the wind must follow the same law. In order to decide this question I selected all those cases in which the wind on the summit of Mt. Washington blew from either the points S., S.E., E. or N.E., according to the hourly observations during the months of May and June, 1873. The number of these cases was 196, and they belong to ten different periods whose duration is shown in column 3d of the following table. Column 2d shows the direction of the wind during this period, and column 4th shows the number of hours at which this wind was observed.

Comparison of winds at the base and summit of Mt. Washington.

No.	On the summit of Mt. Washington.			Surface winds from the East.	
	Wind.	Duration.	H'rs.	Began.	Ended.
1	S. to E.	May 2, 2 P.M. to May 3, 6 P.M.	29	7 h'rs earliest.	4 h'rs latest.
1	S. to E.	May 9, 1 A.M. to May 10, 4 P.M.	40	11 " "	2 " earliest.
3	S.	May 11, 11 A.M. to May 12, 5 A.M.	19	12 " "	8 " earliest.
4	S.	May 21, 11 A.M. to May 21, 4 P.M.	6	12 " "	5 " earliest.
5	S.	May 26, 10 A.M. to M. 26, 11 A.M.	2	Uncertain.	Uncertain.
6	S.E. to N.E.	June 7, 7 P.M. to June 10, 11 A.M.	46	Variable.	Variable.
7	N.E.	June 13, 2 A.M. to June 13, 8 A.M.	4	6 hr's earliest.	Uncertain.
8	S. to S.E.	June 14, 1 P.M. to June 15, 1 A.M.	10	6 " "	2 h'rs latest.
9	S.E. to N.E.	June 22, 9 P.M. to June 25, 3 P.M.	36	Simultaneous.	Variable.
10	S.	June 29, 6 P.M. to June 29, 9 P.M.	4	Simultaneous.	Variable.

In the case of Nos. 6, 7, 8 and 9 the interval named in column 3d exceeds the number of hours mentioned in column 4th, and includes several hours of calms, besides a few hours in which there was a feeble wind from the N. or W. points. Column 5th shows when the surface winds began to blow from S., S.E., E. or N.E.; and column 6th shows when these winds changed to north or west. The time here given for the change of the surface winds is designed to indicate the time of general change at the neighboring stations, and does not depend exclusively upon observations at the base of the mountain. It will be seen that the surface winds generally began to blow from the east several hours before the change took place on the summit of Mt. Washington. The change of wind back from east to west sometimes occurred first at the base and sometimes it occurred first on the summit. The term *variable* in column 6th denotes that the surface winds were feeble, and fluctuated for several hours between east and west.

It will be noticed that during the entire period of the baro-

metric oscillations represented on Plate II, the wind on Mt. Washington never blew from the S., S.E., E. or N.E., and the same is true of the four minima in the months of May and June, 1873, mentioned on page 9. Thus we see that areas of low barometer frequently occur accompanied by surface winds from the south and east, while the winds on Mt. Washington blow uninterruptedly from the western quarter; and in those cases in which the wind on Mt. Washington blows from an eastern quarter, the change from west to east generally occurs first at the base of the mountain.

It is also noticeable that the diurnal movements of the barometer exhibit a peculiarity similar to that found for the accidental fluctuations. This is shown by the following table,

Mean height of the barometer at all hours of the day.

	Mount Washington, New Hampshire.								Mt. Mitchell, N. C.	
	Month of June.				Month of May.		May and June.		August.	
	Stat'n 1	Stat'n 2	Stat'n 3	Stat'n 4	Stat'n 1	Stat'n 4	Sum't.	Base.	Sum't.	Base.
1A.M.	23·818	24·512	25·979	27·179	23·702	27·152	23·760	27·165	23·720	27·355
2	·815	·513	·975	·173	·699	·149	·757	·161	·714	·351
3	·806	·508	·971	·170	·696	·147	·751	·158	·711	·347
4	·802	·511	·976	·175	·690	·146	·746	·160	·706	·349
5	·805	·513	·982	·181	·701	·150	·753	·165	·713	·357
6	·811	·513	·987	·189	·701	·158	·756	·173	·720	·368
7	·817	·520	·993	·196	·707	·164	·762	·180	·731	·373
8	·821	·527	·996	·196	·714	·166	·767	·181	·739	·378
9	·828	·532	·998	·196	·718	·166	·773	·181	·748	·379
10	·838	·536	·999	·196	·725	·165	·781	·180	·753	·374
11	·838	·533	·997	·190	·731	·162	·784	·176	·753	·363
noon	·841	·532	·992	·182	·733	·156	·787	·169	·746	·354
1P.M.	·839	·532	·985	·177	·731	·149	·785	·163	·737	·345
2	·834	·527	·985	·171	·732	·143	·783	·157	·730	·333
3	·830	·528	·976	·161	·725	·142	·777	·152	·726	·330
4	·825	·521	·973	·158	·725	·142	·775	·150	·719	·321
5	·817	·520	·973	·152	·724	·147	·771	·150	·717	·323
6	·822	·517	·973	·156	·721	·154	·771	·155	·717	·329
7	·818	·523	·976	·165	·727	·162	·772	·163	·723	·345
8	·818	·522	·980	·166	·727	·166	·773	·166	·730	·360
9	·826	·531	·984	·173	·733	·170	·779	·171	·737	·361
10	·823	·522	·983	·172	·727	·170	·775	·171	·739	·861
11	·821	·522	·981	·174	·720	·169	·770	·171	·736	·360
midn't	·815	·516	·978	·169	·716	·165	·765	·167	·728	·355

which gives the results derived from the hourly observations published in the Signal Service Report for 1873. Column 2d shows the mean height of the barometer at station 1 (summit of Mt. Washington), at each hour of the day for the month of June. Column 3d shows the mean height of the barometer at station 2 (5,553 feet above sea level); column 4th shows the barometer at station 3 (4,058 feet above the sea); and column

5th shows the barometer at station 4 (2,898 feet above the sea). Columns 6th and 7th show the mean height of the barometer at stations 1 and 4 for the month of May: columns 8th and 9th show the mean height of the barometer at stations 1 and 4 for the months of May and June combined. Column 10th shows the mean height of the barometer at each hour of the day for the month of August, on the summit of Mt. Mitchell, N. C. (elevation 6,691 feet), and column 11th shows the barometer at the base of the mountain (elevation 2,560 feet).

At the base of Mt. Washington the principal maximum occurs at 8½ A. M., but on the summit it does not occur until noon, being a retardation of 3½ hours, which is almost identically the same as we have found on page 7 by a comparison of the accidental fluctuations. At the base of Mt. Mitchell the principal maximum occurs at 8½ A. M., but on the summit it occurs at 10½ A. M., being a retardation of two hours, which also accords remarkably with the result derived on page 10, from the accidental fluctuations.

High Winds on Mount Washington.

In order to study the laws of the winds on Mount Washington, I selected from the published volumes of the Signal Service observations (Sept., 1872 to Jan., 1875) all those cases in which the velocity of the wind was at least sixty miles per hour. The number of these cases was 434, of which 117 occurred at 7.35 A. M., 137 at 4.35 P. M. and 180 at 11 P. M. Thus we see that at 11 P. M. the frequency of high winds is 42 per cent greater than at the other hours of observation. But near the level of the sea the force of the wind at 11 P. M. is generally near its minimum, so that we conclude that the causes which produce high winds on Mount Washington are mainly independent of the causes which determine the ordinary diurnal change in the force of the wind near the level of the sea.

The following table shows the average number of cases of violent winds for each month of the year.

Spring.		Summer.		Autumn.		Winter.	
Mar. 17.5		June 11.5		Sept. 11.7		Dec. 22.7	
Apr. 15.5	14.0	July 6·5	9.2	Oct. 9.7	13.8	Jan. 21.3	21.2
May 9.0		Aug. 9.5		Nov. 20.0		Feb. 19.5	

Thus we see that during the winter months, high winds are twice as frequent as during the summer months, while near the level of the sea high winds are seven times as frequent during the former period as during the latter period.

The following table shows the number of cases in which the wind blew from the different directions at the time of these high velocities.

North,	53 cases.	South,	14 cases.
Northwest,	260 "	Southeast,	8 "
West,	63 "	East,	2 "
Southwest,	27 "	Northeast,	7 "

Thus we see that 60 per cent of all the high winds came from the northwest; 75 per cent came from the west and northwest; 87 per cent came from the west, northwest and north; while only 4 per cent came from the northeast, east and southeast.

In order to determine whether these high winds bear a constant relation to centers of low pressure as indicated by observations near the level of the sea, I prepared a table showing for each date the position of the nearest center of low pressure. This table is so large that I have not thought it expedient to publish it entire, and I have endeavored to abridge it in such a manner as to give a correct idea of the contents of the complete table. In order to equalize the number of examples for the different directions of the wind, I adopted a different standard of velocity for each direction of the wind. For the northwest winds I have employed only velocities amounting to one hundred miles per hour; for the west wind, I have employed velocities of eighty miles per hour; for the north winds velocities of seventy-five miles; for the southwest winds sixty-five miles; for the south sixty miles; for the southeast, fifty-four miles; for the northeast, fifty miles, and for the east winds I have employed all velocities amounting to forty miles per hour. The results are shown in the following table, in which column 1st shows the number of reference, column 2d shows the date of observation; column 3d the direction of the wind, column 4th its velocity in miles per hour, column 6th the position of the nearest center of low pressure, and column 5th the height of the barometer at the station named.

It will be observed that with a north wind of seventy-five miles per hour on Mount Washington there was generally a low center near Halifax, Chatham, Sydney or Cape Rozier. In some cases the center of least pressure had already passed beyond our stations of observation. This remark applies to Nos. 1, 12 and 13. The direction of the wind was nearly at right angles to the direction of the low center. In all these cases the pressure was above thirty inches on the west side of Mount Washington and at a distance of five hundred or six hundred miles; but in a majority of the cases the center of high pressure was southwest of Mount Washington.

With a northwest wind of one hundred miles per hour on Mount Washington there was generally a low center near Halifax, Sydney, Quebec, Father Point or Cape Rozier. In the case of No. 33 (which is the continuation of No. 11) the low center had already passed beyond our stations of observation.

High Winds on Mt. Washington.

No.	Date.	Wind.		Low.	
		Direc.	Vel.	Bar.	Station.
1	'73. Jan. 11.3	N.	76	29·95	Halifax.
2	'74. April 4.3	N.	96	·45	Sydney.
3	11.3	N.	103	·69	Chatham.
4	Sept. 2.1	N.	80	·68	Sydney.
5	Oct. 16.1	N.	80	·77	C. Rozier.
6	19.3	N.	90	·37	Chatham.
7	20.1	N.	90	·56	Chatham.
8	Nov. 11.1	N.	78	·50	C. Rozier.
9	11.3	N.	80	·31	C. Rozier.
10	12.1	N.	76	·50	C. Rozier.
11	29.2	N.	84	·30	Chatham.
12	Dec. 12.2	N.	100	·95	C. Rozier.
13	12.3	N.	80		
14	15.2	N.	75	·75	Sydney.
15	'75. Jan. 23.2	N.	96	·65	Sydney.
16	26.3	N.	98	·40	C. Rozier.
17	27.2	N.	98	·48	Halifax.
18	'73. Feb. 10.2	N.W.	103	·56	Halifax.
19	Mar. 8.3	N.W.	126	·35	Quebec.
20	Aug. 16.3	N.W.	100	·63	Quebec.
21	'74. Jan. 25.3	N.W.	126	·88	Halifax.
22	Feb. 5.2	N.W.	100	·67	Sydney.
23	8.1	N.W.	108	·62	Sydney.
24	11.2	N.W.	100	28·84	Sydney.
25	Mar. 20.3	N.W.	110	29·33	C. Rozier.
26	23.3	N.W.	130	·49	Sydney.
27	24.3	N.W.	102	·78	Sydney.
28	Apr. 30.2	N.W.	130	28·97	Father Pt.
29	30.3	N.W.	115	·99	Father Pt.
30	June 12.3	N.W.	100	29·58	Quebec.
31	13.3	N.W.	108	·76	Sydney.
32	Nov. 5.3	N.W.	100	·64	Quebec.
33	30.3	N.W.	100		
34	Dec. 30.3	N.W.	100	·59	C. Rozier.
35	'75. Jan. 9.3	N.W.	100	·28	Halifax.
36	'72. Nov. 25.2	W.	85	·39	Quebec.
37	Dec. 10.3	W.	84	·73	Quebec.
38	'73. Dec. 4.2	W.	80	·43	Quebec.
39	4.3	W.	96	·29	Chatham.
40	'74. Jan. 23.2	W.	80	·32	Father Pt.
41	23.3	W.	108	·27	C. Rozier.
42	24.1	W.	88	·77	C. Rozier.
43	Feb. 25.3	W.	90	·47	Father Pt.
44	Mar. 24.2	W.	115	·67	Sydney.
45	June 8.1	W.	90	·45	Quebec.
46	Oct. 29.3	W.	92	·57	Montreal.
47	Nov. 5.2	W.	82	·67	Father Pt.
48	Dec. 14.3	W.	94	·28	Sydney.
49	18.1	W.	80	·18	Halifax.
50	'72. Nov. 12.2	S.W.	65	·72	Montreal.
51	Dec. 21.3	S.W.	65	·88	Oswego.
52	'73. Jan. 16.2	S.W.	74	·45	Buffalo.
53	16.3	S.W.	72	·36	Quebec.
54	Sept. 25.3	S.W.	65	·81	Montreal.
55	Nov. 27.2	S.W.	72	·55	Father Pt.
56	Dec. 4.1	S.W.	65	28·91	Marquette
57	'74. Jan. 4.3	S.W.	80	29·55	Father Pt.
58	7.1	S.W.	65	·53	Ft. Garry.
59	Feb. 23.1	S.W.	82	·58	Rochester.
60	Mar. 3.3	S.W.	96	·33	Erie.
61	4.1	S.W.	74	·34	Ottawa.
62	'74. Oct. 29.2	S.W.	68	29·49	Alpena.
63	Dec. 11.1	S.W.	70	·79	Ottawa.
64	'75. Jan. 9.1	S.W.	73	·72	Parry Sd.
65	13.2	S.W.	65	·64	Parry Sd.
66	'73. Jan. 5.2	S.	64	·45	Buffalo.
67	5.3	S.	60	·34	Oswego.
68	8.3	S.	66	·40	Marquette
69	13.3	S.	80	·68	Montreal.
70	Mar. 11.2	S.	77	·41	Montreal.
71	31.3	S.	82	·62	Portland.
72	April 9.3	S.	89	·47	Marquette
73	'74. Apr. 20.2	S.	60	·40	Rochester.
74	May 16.1	S.	68	·55	Saugeen.
75	18.3	S.	60	·69	Quebec.
76	June 16.	S.	60	·70	Ottawa.
77	Nov. 20.2	S.	60	·38	Portland.
78	28.3	S.	70	·85	Atlantic C.
79	'75. Jan. 24.2	S.	60	·63	Buffalo.
80	'72. Dec. 3.2	S.E.	60	·58	Quebec.
81	8·2	S.E.	54	·47	Montreal.
82	'73. Mar. 20.3	S.E.	84	·36	Toronto.
83	Aug. 14.2	S.E.	60	·78	Lynchb'g.
84	14.3	S.E.	60	·82	Pittsburg.
85	18.2	S.E.	60	·90	Pittsburg.
86	Oct. 20.1	S.E.	75	·45	Cape May.
87	20.2	S.E.	78	·26	Philadel'a.
88	21.1	S.E.	55	·28	Erie.
89	Nov. 17.3	S.E.	56	28·82	Cape May.
90	'74. Jan. 8.1	S.E.	62	29·32	Ottawa.
91	Sept. 17.3	S.E.	58	·56	Pembina.
92	Nov. 23.1	S.E.	54	28·75	Alpena.
93	'72. Oct. 7.1	E.	45	29·83	Oswego.
94	Dec. 6.1	E.	42	·95	Quebec.
95	'73. Apr. 12.3	E.	96	·51	N. London
96	May 3.2	E.	48	·58	N. London
97	9.2	E.	48	·61	Gd.Haven.
98	Nov. 18.1	E.	48	28·66	N. London
99	24.2	E.	58	29·27	Boston.
100	'74. Apr. 10.1	E.	52	·49	Cape May.
101	25.3	E.	58	·32	Cape May.
102	26.1	E.	90	·13	Boston.
103	May 21.3	E.	50	·63	Portland.
104	July 4.3	E.	44	·72	New York
105	Sept. 29.3	E.	54	·24	N. London
106	Oct. 8.3	E.	50	·81	Barnegat.
107	'72. Oct. 31.2	N.E.	50	·91	N. London
108	31.3	N.E.	72	·79	Portland.
109	Dec. 10.2	N.E.	62	·60	Quebec.
110	20.1	N.E.	55	·43	Buffalo.
111	20.2	N.E.	52	·50	Montreal.
112	28.1	N.E.	60	·49	Halifax.
113	28.2	N.E.	55	·81	Halifax.
114	28.3	N.E.	72	·94	Halifax.
115	29.1	N.E.	54		
116	'73. Feb. 17.1	N.E.	60	·63	N. London
117	24.1	N.E.	52	·24	Quebec.
118	Apr. 12.2	N.E.	70	·52	New York
119	13.1	N.E.	58	·61	Boston.
120	Oct. 8.2	N.E.	50	·69	Halifax.
121	8.3	N.E.	60	·91	N. London

In twelve of the cases the stations which show the lowest pressure are the same as reported above for the north winds, but in six of the cases the lowest pressure was farther to the west. The average direction of the low center from Mount Washington was nearly at right angles to the direction of the winds. In all of these cases (except Nos. 28 and 29) the pressure was above thirty inches on the west side of Mount Washington and generally at a distance of about five hundred miles, but in a majority of the cases the center of high pressure was southwest of Mount Washington.

With a west wind of eighty miles per hour, the low center was generally near some one of the stations already named. In six of the cases the low center was near one of the stations named for the north winds; in twelve of the cases the low center was near one of the stations named for the northwest winds; and in one case (No. 46) the low center was farther west than was found for the north or northwest winds. The angle which the wind's direction made with the direction of the station reporting the least pressure ranges from about zero to somewhat over 90°. On account of the small number of stations, it is generally impossible to assign exactly the position of the center of least pressure, but apparently the angle which the wind's direction made with the direction of the low center was in some cases less than 45°. In all of these cases (except Nos. 45 and 47) the pressure was above thirty inches on the west side of Mount Washington and generally at a distance of about eight hundred miles; but in all cases the center of high pressure was somewhat south of west from Mount Washington.

With a southwest wind of sixty-five miles per hour, the direction of the station reporting the lowest pressure ranges from N. 25° E. to S. 75° W., the average direction of the low center making an angle of about 90° with the direction of the wind. In the case of No. 58 there was a low center in Virginia and a low center at the same time in Manitoba, and both seemed to exert an influence upon the direction of the wind on Mount Washington. In six of these cases the center of high pressure was southwest of Mount Washington, but in the remaining ten cases its direction was almost exactly west, and its distance about 1,300 miles.

With a south wind of sixty miles per hour on Mount Washington the low center is generally found nearly west from that station. The exceptions are Nos. 71, 75, 77 and 78. In the case of seventy-one we find the pressure at Montreal was less than at Burlington, so that it appears possible that at the height of 6,000 feet the center of least pressure was not over Portland but northwest of Montreal. In the case of seventy-five the pressure at Ottawa was only ·07 inch greater than at

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Quebec; in the case of seventy-seven the pressure at Kingston was only ·02 inch greater than at Portland; and in seventy-eight the pressure at Albany was only ·05 inch greater than at Atlantic City; so that it appears not improbable that at the height of 6,000 feet the center of least pressure at each of these four dates was west of Mount Washington. In each of these cases there was a center of high pressure in a direction west or southwest from Mount Washington and at an average distance of 1,100 miles. It is presumed there was also an area of high pressure on the east side of Mount Washington, but it had already passed beyond our stations of observation.

With a southeast wind of fifty-four miles per hour on Mount Washington the low center falls between the directions south and northwest. The only exception is No. 80 and this case seems to indicate that at the height of 6,000 feet the low center was nearly two hundred miles in arrears of the low center at the surface of the earth. In each of these cases there was an area of high pressure west or southwest of Mount Washington. Generally its direction was nearly west and its distance about 1,200 miles. The center of high pressure on the east side had generally passed beyond our stations of observation, but in the case of No. 91, the pressure at Cape Rozier was 30·67 inches, and the distance of the center of low pressure was more than twice as great as usual.

With an east wind of sixty miles per hour the low center is generally found nearly south of Mount Washington. The exceptions are Nos. 93, 94, 97 and 103. In the case of Nos. 93 and 97, observations at other stations place the low center considerably south of Oswego and Grand Haven; and in the case of No. 103, observations at other stations place the low center west of Portland. The position of the areas of high pressure is nearly the same as for the southeast winds.

With a northeast wind of fifty miles per hour the low center is generally found south or southeast of Mount Washington. The exceptions are Nos. 109, 110, 111 and 117. In the case of Nos. 109 and 117 no observations were made near the Atlantic coast at any station east of Portland, and it is probable that at these dates the low center was not far from Halifax. In the case of Nos. 110 and 111 the low center came from the southwest, and the minimum of pressure on Mount Washington occurred fifteen hours later than at Burlington or Portland. It seems probable therefore that at the height of 6,000 feet the low center was considerably southwest of its position at the surface of the earth. In the case of No. 115 the low center had already passed beyond Halifax, which was the most eastern station of observation.

The examination of these one hundred and twenty-one cases

seems to warrant the following conclusions: 1. High winds on Mount Washington circulate about a low center as they do near the level of the sea. 2. The motion of the wind is nearly at right angles to the direction of the low center. 3. The low center at the height of Mount Washington sometimes lags behind the low center at the surface of the earth apparently as much as two hundred miles.

High Winds on Pike's Peak.

In order to study the laws of the winds on Pike's Peak, I selected from the published volumes of the Signal Service observations (November, 1873 to January, 1875) all those cases in which the velocity of the wind was as great as thirty miles per hour. The number of these cases was 363, of which 136 were reported at 7.35 A. M., 97 at 4.35 P. M., and 130 at 11 P. M. Hence it appears that at 4.35 P. M. high winds are twenty-five per cent less frequent than at the other two hours of observation. But near the level of the sea the average force of the wind at 4 P. M. is double that at the other two hours, which results accord with the Mt. Washington observations in indicating that these high winds are mainly independent of the causes which determine the diurnal change at the level of the sea.

The average number of cases of violent winds for each month of the year is as follows:

Spring.		Summer.		Autumn.		Winter.	
March 14		June 21		Sept. 17		Dec. 28.5	
April 17	15.7	July 2	11.3	Oct. 24	26.5	Jan. 42	31.2
May 16		Aug. 11		Nov. 38.5		Feb. 23	

Thus we see that during the winter months high winds are nearly three times as frequent as during the summer months.

The following table shows the number of cases in which the wind blew from the different directions at the time of these high velocities.

North,	28 cases.	South,	18 cases.
Northwest,	47 "	Southeast,	1 case.
West,	154 "	East,	0 "
Southwest,	111 "	Northeast,	4 cases.

Thus we see that seventy-three per cent of these high winds come from the west and southwest, and only one per cent comes from any easterly point.

In order to determine whether these high winds bear a constant relation to centers of low pressure near the level of the sea, I have prepared a table similar to that on page 16. For the west winds I have employed all velocities amounting to fifty-five miles per hour; for the southwest winds I have employed velocities of fifty miles per hour; for the northwest winds velocities of forty-two miles per hour; for the north winds thirty-five miles per hour; for the south winds thirty-

two miles per hour; for the northeast winds twenty-two miles per hour; for the southeast winds ten miles per hour, and for the east winds I have employed all velocities amounting to seven miles per hour. The following table is arranged in the same manner as that on page 16. For No. 47 the velocity of the wind is given seventy-seven miles according to the published observations; but I am informed by General Myers that this velocity should be thirty miles.

It will be observed that with a north wind of thirty-five miles per hour on Pike's Peak, there was generally an area of low pressure on the east side of that station. In the case of No. 11, throughout the entire United States the barometer was above thirty inches, but a low center was forming near Mobile which on the next day developed into a storm of considerable intensity. We also find that there was generally an area of high pressure in a direction west or northwest from Pike's Peak.

With a northwest wind of forty-two miles per hour, there was generally an area of low pressure on the northeast side of Pike's Peak. No. 23 is the same case as No. 11 noticed above. We also find that there was generally an area of high pressure on the Pacific coast.

With a west wind of fifty-five miles per hour, there was generally an area of low pressure in a northeast direction from Pike's Peak, and an area of high pressure on the Pacific coast. No. 40 is the same case as Nos. 11 and 23 noticed above.

With a southwest wind of fifty miles per hour, there was generally an area of low pressure in a northerly direction from Pike's Peak, and an area of high pressure on the Pacific coast or on the coast of Texas.

With a south wind of thirty-two miles per hour, there was generally an area of low pressure in a northerly direction from Pike's Peak. Frequently the center of low pressure appeared to be in a direction east of north. If there had been more westerly stations of observation it is presumed that in some of these cases the center of least pressure would have been found west of Bismark and Fort Sully. In the case of No. 73 an area of low pressure was forming near Pike's Peak, which became fully developed the next day. We also find that the pressure was generally somewhat above the mean in a direction southeast from Pike's Peak.

With a southeast wind of not less than ten miles per hour, there was generally an area of low pressure at no great distance, but in half of the cases the lowest observed pressure was on the northeast side of Pike's Peak. All but three of the cases occurred in summer, and the average velocity of the wind was only sixteen miles per hour. We also find that on the east side of Pike's Peak, the pressure was in each case a little above thirty inches.

High Winds on Pike's Peak.

No.	Date.	Wind.		Low.		No.	Date.	Wind.		Low.	
		Direc.	Vel.	Bar.	Station.			Direc.	Vel.	Bar.	Station.
1	'73. Nov. 17.3	N.	35	29·27	St. Louis.	62	'74. Apr. 12.1	S.	32	29·49	Ft. Sully.
2	18.2	N.	35	·23	Augusta.	63	May 27.3	S.	48	·24	Ft. Sully.
3	Dec. 26.1	N.	40	·41	Escanaba.	64	July 17.3	S.	32	·65	Ft. Sully.
4	26.3	N.	40	·48	Detroit.	65	Aug. 25.1	S.	40	·82	Salt Lk. C.
5	'74. Jan. 6.1	N.	40	·90	Montgom.	66	Oct. 22.3	S.	32	·82	Bismark.
6	May 2.3	N.	40	·35	Leavenw.	67	23.3	S.	40	·65	Salt Lk. C.
7	3.1	N.	36	·43	Leavenw.	68	24.1	S.	36	·66	Salt Lk. C.
8	Aug. 3.3	N.	36	·82	Ft. Sully.	69	24.3	S.	60	·24	Bismark.
9	Nov. 24.3	N.	55	·75	N.Orleans.	70	26.2	S.	40	·89	Salt Lk. C.
10	25.1	N.	35	·74	Jacksonv.	71	26.3	S.	50	·88	Salt Lk. C.
11	28.1	N.	35			72	27.3	S.	68	·64	Cheyenne.
12	Dec. 17.3	N.	40	·85	Santa Fé.	73	Nov. 15.3	S.	38		
13	21.3	N.	45	·62	St. Paul.	74	Dec. 14.2	S.	32	·87	Bismark.
14	23.2	N.	45	·49	Marquette	75	25.2	S.	40	·78	Salt Lk. C.
15	'73. Nov. 17.1	N.W.	65	·41	Duluth.	76	27.2	S.	32	·59	Bismark.
16	'74. Jan. 7.1	N.W.	42	·53	Ft. Garry.	77	'75. Jan. 15.2	S.	40	·70	Cheyenne.
17	8.1	N.W.	50	·42	Ft. Garry.	78	17.2	S.	42	·71	Cheyenne.
18	Apr. 13.1	N.W.	44	·30	Ft. Garry.	79	'74. Feb. 21.1	S.E.	24	·48	Santa Fé.
19	Sept. 16.2	N.W.	50	·54	Ft. Sully.	80	Apr. 17.1	S.E.	12	·59	Santa Fé.
20	Nov. 4.2	N.W.	44	·20	Bismark.	81	May 6.3	S.E.	30	·60	Salt Lk. C.
21	20.1	N.W.	46	·64	Breckenr.	82	June 21.3	S.E.	16	·68	Ft. Sully.
22	22.1	N.W.	65	·21	Breckenr.	83	22.2	S.E.	14	·44	Ft. Sully.
23	28.2	N.W.	55			84	28.3	S.E.	12	·71	Santa Fé.
24	28.3	N.W.	58	·85	Atlantic C.	85	July 2.2	S.E.	10	·45	Ft. Sully.
25	Dec. 9.3	N.W.	45	·74	Father Pt.	86	13.2	S.E.	16	·60	Ft. Sully.
26	28.1	N.W.	60	·73	Alpena.	87	17.2	S.E.	10	·60	Ft. Sully.
27	'75. Jan. 2.3	N.W.	42	·86	Cheyenne.	88	21.3	S.E.	12	·80	Pembina.
28	'74. Feb. 13.1	W.	60	·33	Detroit.	89	Aug. 8.2	S.E.	12	·72	Pembina.
29	Oct. 28.1	W.	60	·34	Omaha.	90	19.3	S.E.	24	·87	Portl'd, O.
30	28.2	W.	55	·28	St. Paul.	91	20.2	S.E.	12	·60	Ft. Sully.
31	Nov. 4.3	W.	60	·31	Bismark.	92	24.3	S.E.	28	·78	Salt Lk. C.
32	7.3	W.	56	·16	Duluth.	93	'74. May 30.2	E.	20	·86	San Franc.
33	8.1	W.	70	·34	Duluth.	94	June 30.2	E.	12	·81	San Franc.
34	8.3	W.	65	·68	Marquette	95	July 6.2	E.	16	·91	San Diego.
35	9.1	W.	60	·61	Bismark.	96	19.2	E.	8		
36	13.1	W.	62	·77	Bismark.	97	19.3	E.	28		
37	21.1	W.	60	·38	Bismark.	98	20.2	E.	8		
38	23.1	W.	75	28·75	Alpena.	99	Aug. 17.1	E.	12	·91	San Diego.
39	24.1	W.	65	·89	C. Rozier.	100	23.1	E.	8	·89	San Diego.
40	27.3	W.	55			101	23.3	E.	8	·87	San Diego.
41	Dec. 22.2	W.	55	29·39	Bismark.	102	Oct. 1.2	E.	11	·84	Salt Lk. C.
42	24.1	W.	60	·60	Alpena.	103	4.2	E.	7	·88	San Franc.
43	'75. Jan. 7.1	W.	62	·70	Cheyenne.	104	4.3	E.	12	·89	Portl'd, O.
44	9.2	W.	60	·72	Quebec.	105	14.2	E.	16	·97	San Franc.
45	19.3	W.	55	·68	Cheyenne.	106	'73. Nov. 18.1	N.E.	43	·81	Galveston.
46	'74. May 28.1	S.W.	55	·59	Breckenr.	107	18.3	N.E.	36	·85	Montgom.
47	June 1.2	S.W.	77	·75	Ft. Sully.	108	Dec. 12.2	N.E.	22	·67	Cairo.
48	10.1	S.W.	55	·68	Yankton.	109	24.3	N.E.	24		
49	27.1	S.W.	52	·50	Yankton.	110	'74. Feb. 6.1	N.E.	36	·93	Nashville.
50	Sept. 11.1	S.W.	55	·58	Ft. Sully.	111	Apr. 18.1	N.E.	24	·84	Galveston.
51	Oct. 24.2	S.W.	52	·23	Bismark.	112	July 7.1	N.E.	24	·81	Omaha.
52	27.2	S.W.	54	·76	Cheyenne.	113	7.3	N.E.	22	·78	Leavenw.
53	Nov. 6.1	S.W.	64	·30	Bismark.	114	8.2	N.E.	22	·56	Omaha.
54	6.2	S.W.	60	·28	Bismark.	115	27.3	N.E.	28	·82	Ft.Gibson.
55	13.2	S.W.	60	·53	Ft. Sully.	116	Sept. 8.2	N.E.	23	·84	Ft.Gibson.
56	Dec. 24.2	S.W.	65	·58	Ft. Sully.	117	23.2	N.E.	24	·84	Galveston.
57	24.3	S.W.	50	·50	Ft. Sully.	118	23.3	N.E.	28	·85	Shrevep't.
58	'75. Jan. 7.2	S.W.	62	·59	Cheyenne.	119	24.1	N.E.	36	·85	Shrevep't.
59	10.2	S.W.	50	·76	Cheyenne.	120	24.2	N.E.	22	·80	Shrevep't.
60	15.1	S.W.	54	·50	Cheyenne.	121	24.3	N.E.	22	·87	Ft.Gibson.
61	16.3	S.W.	55	·86	Cheyenne.						

With an east wind of not less than seven miles per hour on Pike's Peak, the pressure on the Pacific coast was generally somewhat less than thirty inches, while on the east side of that station the pressure was a little greater than thirty inches, but at Santa Fé the pressure at these dates was not sensibly below the mean. The average velocity of the wind was only twelve miles per hour. The majority of these cases occurred in summer, and none occurred during the colder half of the year.

With a northeast wind of twenty-two miles per hour, a pressure less than thirty inches was generally found on the east side of Pike's Peak, its average direction being about southeast. Also a pressure greater than thirty inches was generally found on the north or northwest side of Pike's Peak, but in half of the cases the difference between these two pressures did not exceed a quarter of an inch.

Comparing the preceding results with those before found for Mt. Washington, we see that with a high wind from the north, northwest, west, or southwest, the position of the areas of low pressure is similar at both stations, but the centers of least pressure are frequently more remote from Pike's Peak, and are more widely scattered This difference may be partly explained by the small number of stations east and north of Mt. Washington. With a high south or southeast wind on Pike's Peak the position of the low center is sometimes apparently east of north. Similar anomalies are sometimes noticed on Mt. Washington, but they admit of a plausible explanation. We also notice that with a low center at a given locality, the high winds on Pike's Peak may have a great variety of directions. Thus when there is a low center at Fort Sully, we find high winds on Pike's Peak from north, northwest, southwest, south, and southeast. When there is a low at Bismark or Cheyenne we find high winds on Pike's Peak from northwest, west, southwest and south. This result may be in part ascribed to the small number of stations near the Rocky Mountains, which renders it difficult to assign the precise position of the center of least pressure. It also appears that the direction of the wind on Pike's Peak depends partly upon the position of the areas of high pressure, but this direction seems to be influenced by circumstances which cannot be clearly assigned from the want of observations at a sufficient number of stations.

With an east or northeast wind on Pike's Peak, there is generally no low center of much magnitude indicated at any of the stations, and the average difference between the high on one side and the low on the other is only one-third of an inch. Hence we conclude that while high winds on Pike's Peak from the directions north, northwest, west and southwest indicate a circulation about a low center according to the same law

as is observed near the level of the sea, the winds from the south, southeast, east and northeast give only obscure indications of being governed by this law.

The winds observed on Pike's Peak from the east and southeast are very few in number, particularly during the colder portion of the year. The following table shows the total number of easterly winds for each month during a period of three years from observations made three times a day.

	S.E.	E.	N.E.		S.E.	E.	N.E.		S.E.	E.	N.E.
Jan.	2	0	4	May	6	6	19	Sept.	5	4	36
Feb.	1	0	3	June	6	2	12	Oct.	2	9	19
Mar.	1	0	13	July	9	12	49	Nov.	1	0	10
Apr.	4	0	15	Aug.	7	8	25	Dec.	2	2	19

Thus we see that during the six months from November to April, an east wind was observed only twice in a period of three years. In one of these cases the velocity of the wind was six miles per hour, and in the other case three miles. The winds from east and southeast constitute less than three per cent of all the winds, whereas in the same latitude near the level of the sea the winds from these directions constitute twenty per cent of the whole number. We also notice that on Pike's Peak easterly winds are four times as frequent in summer as in winter, which seems to indicate that these winds are dependent upon difference of temperature more than upon difference of pressure. On the elevated plateau west of Pike's Peak are extensive regions where the temperature is as high as it is on the east side at a much lower level; whence it may result that at the height of Pike's Peak the temperature of the air on the west side is sometimes sensibly greater than it is on the east side.

The only station of the Signal Service whose direction is nearly south from Pike's Peak is Santa Fé. I have examined these observations to see what was the direction of the wind on Pike's Peak at the time of low barometer at Santa Fé. The following table shows all the cases in which there was a considerable depression at Santa Fé during the period of the published observations at Pike's Peak. Column second shows the date of the minimum; column third shows the lowest observation of the barometer; column fourth shows the direction and force of the wind at Santa Fé; column fifth shows the direction and force of the wind on Pike's Peak at the date named in column second; column sixth shows the wind on Pike's Peak at the time of the last preceding observation; and column seventh shows the position of the center of the nearest low area as shown by the observations.

Low barometer at Santa Fé.

No.	Date.	Santa Fe.			Wind on Pike's Peak.			Low.
		Bar.	Wind.		At date.		Prev. ob.	
1	'73. Nov. 22.2	29·51	Calm.		N.E.	20	Calm.	Ft. Gibson.
2	Dec. 2.2	·31	S.W.	26	S.W.	15	S.W. 20	Leavenworth.
3	7.2	·51	S.E.	8	S.W.	32	S.W. 18	Corinne.
4	'74. Jan. 2.2	·59	S.W.	6	S.W.	20	W. 40	Ft. Sully.
5	21.2	·38	S.W.	12	W.	10	W. 15	Cheyenne.
6	Feb. 12.2	·18	W.	24	W.	25	W. 16	Dubuque.
7	18.3	·39	S.	8	W.	8	S.W. 20	Ft. Sully.
8	21.2	·28	S.E.	12	S.W.	20	S.E. 24	Santa Fé.
9	24.1	·43	E.	12	S.W.	18	S.W. 16	Santa Fé.
10	Mar. 5.2	·26	S.W.	22	S.W.	12	S.W. 12	Cheyenne.
11	16.2	·18	S.W.	20	S.W.	16	W. 24	Ft. Sully.
12	30.1	·46	S.	16	S.	14	S.W. 20	Salt Lake City
13	April 6.2	·42	S.W.	30	S.	6	W. 15	Salt Lake City
14	12.2	·42	N.W.	20	N.	26	S. 32	Ft. Sully.
15	May 1.3	·41	W.	20	W.	24	S.W. 20	Leavenworth.
16	9.1	·44	S.W.	12	S.W.	20	S.W. 36	Ft. Sully.
17	Oct. 24.2	·59	S.W.	8	S.W.	52	S. 36	Bismark.
18	Nov. 3.2	·57	S.W.	8	S.W.	30	S.W. 40	Bismark.
19	21.3	·33	S.E.	12	S.W.	28	S.W. 32	Bismark.
20	26.2	·48	S.W.	4	W.	22	W. 20	Duluth.
21	Dec. 15.2	·55	S.W.	12	N.W.	26	W. 12	Ft. Sully.
22	21.1	·50	S.	8	N.E.	4	N.W. 10	Santa Fé.
23	27.1	·41	S.E.	4	S.	15	S.W. 20	Colorado Spr.
24	'75. Jan. 5.2	·42	Calm.		S.W.	15	S.W. 22	Cheyenne.
25	12.1	·35	S.	4	S.W.	1	S.W. 10	Salt Lake City
26	28.1	·41	N.E.	4	Calm.		W. 15	Corsicana.

We see that the center of low pressure generally passes north of Pike's Peak, and there are only six cases in which the low was south of Pike's Peak, viz: Nos. 1, 8, 9, 22, 23 and 26. In the case of Nos. 1 and 22 the wind on Pike's Peak was northeast; in No. 23 it was from the south; in No. 26 it was calm; in No. 8 it was southeast at the time of the last preceding observation; in No. 9 it was southwest and had been blowing from some western quarter for a period of forty-eight hours. The first five cases accord tolerably well with the results found for the winds on Mt. Washington, but No. 9 seems to indicate that the system of circulating winds which prevailed at that date at lower stations did not extend as high as Pike's Peak. We see that one reason why easterly winds are so rare on Pike's Peak, particularly during the winter months, is that the low centers generally pass north of that mountain.

The preceding investigation seems to warrant the following conclusions, which are an extension of those stated on page 19.

1. At the height of 6,000 feet the winds circulate about centers of low pressure as they do near the level of the sea, but frequently the position of the center of low pressure is sensibly different at the height of Mt. Washington from what it is at

lower stations, and we sometimes find low areas resulting from a circulation of the surface winds which does not extend to the height of 6,000 feet.

2. At the height of 14,000 feet the fluctuations of the barometer are quite large, but the centers of low pressure at this elevation differ in position from those at lower stations, so that frequently there appears to be but little correspondence between the movements of the wind on Pike's Peak and the fluctuations of pressure at the lower stations, and we frequently find areas of low pressure resulting from a circulation of the surface winds which does not extend to the height of 14,000 feet.

In preparing the materials for this article I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College of the class of 1871.

Art. II.—*Notes on the Mesozoic Strata of Virginia;* by Wm. M. Fontaine.

In this paper I present a summary of the results attained by a series of examinations, made in the Mesozoic strata of Virginia. These examinations have occupied the larger portion of my summer vacations for several years. Some of my conclusions were reached sometime ago, but as the field presents many difficulties in its study, and as I arrived at some unexpected results, I was not willing to present them until I had made repeated observations, and at remote points. As I have been very slow myself to reach some of these conclusions, I must expect that others will require convincing evidence before accepting them. Such evidence perhaps cannot be presented in the limits of an article. To deal fully with my material, whether stratigraphical, lithological, or derived from the fossil plants, will require an extended memoir. I hope soon to present this.

The great denudation which the Mesozoic beds and the enclosing crystalline or Azoic rocks have undergone, the proneness of the former to fall into a loose incoherent mass, the covering of drift matter and clay which often conceals the outcrops, all unite to render the task of studying the Mesozoic of Virginia a very laborious and difficult one.

It is due to Professor Wm. B. Rogers to state that his careful and accurate observations, made in the early surveys of Virginia, have rendered my work very much easier than it would otherwise have been; much that I have observed is merely a confirmation of what he had already noted. He has given correctly the location, boundaries and general character

of the several Mesozoic areas, but as the relations of some of these do not seem to be understood, it will be necessary for me to give here some of these features with explanations. It will be understood, as was shown by Professor Rogers, that in Virginia the Cretaceous, if it exists, does not appear to view, hence the term Mesozoic includes only strata older than Cretaceous. In Virginia the Jurassic forms the youngest Mesozoic, and is overlaid by the Tertiary.

The several Mesozoic Belts.—The largest and most important Mesozoic belt is that which enters the State from Maryland, west of Washington, being the continuation of the tract so largely developed in New Jersey. For the sake of distinction it may be called the *New Jersey Belt.* It has all the features seen in its exposures farther north, and I have no reason to doubt its being of Triassic age. So far as can be ascertained from the scanty attainable evidence, it is in part, the oldest of the Virginia Mesozoic. It extends unbroken to the Rapidan River in Orange County, and has to the south, a few miles distant, a small outlier now separated from it owing to erosion.

A second narrow belt, a mere remnant which has escaped erosion, is found on James River, in the northern part of Buckingham County. This is now widely separated from the preceding belt, but possibly, though not probably, it once formed a part of it. This may be called the *Buckingham Belt.* A third narrow belt extends from the North Carolina border, near the Dan River, in a northeast direction through Pittsylvania into Campbell County. It has a width of four to eight miles, and a length of about thirty miles. Though now separated by a narrow interval from the Dan River Coal Field in North Carolina, it no doubt was once connected with it. This may be called the *Pittsylvania Belt.*

A fourth narrow belt extends northeast from Prince Edward into Cumberland County. It contains in its southern extremity a coal bed which is worked locally, and is the only belt except the Richmond Coal Field which contains any coal. This may be called the *Prince Edward Belt.* All of these four belts have many features in common. They have all suffered greatly from erosion. They have a northwest dip of varying steepness which extends unreversed across each belt. It is quite possible that the last two were once connected, but if so, it would seem to have been by narrow arms or inlets. Except in very rare cases these belts, and the enclosing Azoic rocks, have all been planed down to a uniform level. These four belts may be grouped as interior belts.

Passing to the east we find a fifth belt, nearly enclosed by Azoic rocks, but at its northern end touching later formations. This, which we may call the *Richmond Belt*, begins a

short distance south of the Appomatox River in Amelia County, and extends in a direction a little east of north to the vicinity of Chesterfield Station, in Caroline County, on the Richmond, Fredericksburg and Potomac Railroad, where it is overlapped by later formations. On the Chickahominy River, northwest of Richmond, this belt is broken by an interval of Azoic rocks three miles wide, which separates the northern from the southern portions. The southern portion alone yields coal, and as it differs somewhat from the northern portion, we may give it the distinctive name of the Richmond Coal Field, while the northern portion lying mainly in Hanover County, may be called the Hanover area. No doubt the two were once connected by at least their latest formed beds. Both sections of the belt have suffered much from erosion, and we find here again the striking feature of the planing down of the yielding beds of the Mesozoic, to the same level with the most resistant Azoic strata. The coal field is separated from the Tertiary on the east by a belt of granite and gneissoid granite about twelve miles wide. This belt seems always to have formed the eastern border, cutting off the southern end of the coal field from communication with the open sea. It is by the sinking down of this granitic border to the north, that the Tertiary beds are enabled in that quarter to overlap the Mesozoic of the Hanover area. The northern end of the coal field proper sends finger-like projections into the Azoic, which are the deepest portions of troughs which have escaped erosion. Some of these are entirely isolated from the main field. They sometimes furnish very instructive sections, throwing light upon the geological history of the coal field.

Still farther east, and differing in position from all the preceding belts, we find two others geographically distinct, but geologically the same. These lie east of, and outside of the Azoic rocks, and are really a shore formation, which must have extended to the open sea, though the indications are that the communication was very imperfect. Owing to their apparent distinctness we must consider them separately.

The sixth belt, or the first of these border belts, begins at Petersburg and extends along the eastern edge of the Azoic rocks, in a direction almost due north, past Richmond to near the termination of the Hanover area, which it overlaps on its eastern side. In this quarter, the uppermost beds of the Hanover area appear to pass into the lowest of the belt in question, and both are overlaid by the Tertiary. It is quite possible that this belt, if it could be traced farther east, under the Tertiary, would be found to extend unbroken farther south. At any rate, Professor Rogers states that a small patch of strata of the same character is exposed in the bed of the Nottaway River

in Sussex County, twenty miles south of Petersburg. In this direction the Tertiary strata overlap the Azoic, and bury the subjacent formations too deeply for the erosion of the streams to expose them, except in the locality mentioned. Professor Rogers, in his earlier reports, stated that an area of Mesozoic exists near Hick's Ford, but in his later reports, he states that the above-mentioned locality is the farthest point to the south at which the Mesozoic is found. I have not visited this place. South of the Nottaway, no traces of the Mesozoic have been seen. This belt may be called the *Petersburg Belt.* A seventh belt similar to the last is found nearly in the prolongation of it in a direction due north. This begins a little south of Fredericksburg and continues along the eastern border of the Azoic, in a northerly direction. Its western margin passes several miles west of Alexandria. As it passes out of the State it bends to the northeast, so as still to hug the eastern margin of the Azoic. So far as I have traced it, it extends at least as far north as Baltimore. This may be called the *Fredericksburg Belt.* Both the last mentioned belts always are found on the east of the Azoic, and are never seen invading it. In Virginia they dip eastward under the Eocene, and in Maryland under the Cretaceous. The dip is usually to some point in the southeast, and is very gentle. It is quite probable that these two belts are connected farther east, under the Tertiary, but along the margin of the Azoic they are separated by a considerable interval of the Tertiary, where this latter overlaps the Azoic. Geologically they form one area, which is very distinct from the Richmond belt. It is the relation of this border formation with the Richmond belt which is usually misunderstood. As we shall see, when we consider the character of the strata contained in them they differ greatly, and simply touch in Hanover County, where the different directions of the several areas cause them to meet at an acute angle. The statement made in the revised edition of Dana's Manual gives the usually accepted opinion. This statement is that the Richmond area begins on the Potomac, and extends south to the Appomatox River. I shall speak of these two belts as the border belts, and they are distinguished as the Petersburg and Fredericksburg belts as above stated. My studies of the Mesozoic in Virginia have been confined almost entirely to the border belts, and to portions of the Richmond belt, as these offered the most promising field.

The existence of all these belts, except the border ones, is due, I think, to the gradual depression of certain elongated tracts in the Azoic which have approximately the direction of the strike of the Azoic strata. The location of these depressed areas is fixed by the previous establishment of lines of weakness, by the processes producing the metamorphism of the

Azoic. The force producing the sinking along these lines was plainly a lateral thrust, which at least in the case of the Richmond belt, acted from east to west. The sinking seems to have commenced at or near the close of the Permian period, and to have continued till toward the close of the Jurassic. The depression was accompanied by, in many cases, extremely rapid sedimentation, and toward its end, produced a rupturing of the crust and an outpour of fused rock.

Wherever I have had an opportunity to examine carefully the Azoic rocks bordering the Mesozoic belts, I find them penetrated by dykes of true igneous matter, such as felsite, granite, diabase, etc., which are much older than the Mesozoic beds. These dykes run parallel with the Mesozoic belts, and are confined to their vicinity. Their presence indicates that in the general metamorphism of the country, fracturing of the crust took place, and the metamorphic action was excessive along certain lines. There is no doubt in my mind that this previous weakening of the crust in definite belts, has much to do with the subsequent emission of the Mesozoic trap rocks in such well defined areas as we find to exist. I find also here a good example of the application of Von Richthoven's conclusions concerning the order of precedence, and the association of igneous rocks.

Topography.—The topography of the Azoic, and the included Mesozoic areas, is very significant, and may be studied to great advantage in Virginia. What I shall say under this head is more particularly applicable to the district which is limited on the north by the Potomac, on the south by the Appomatox, on the east by the Tertiary, and on the west by the Catoctin range of mountains. I apply this, the Maryland name, to that more or less connected range which penetrates far into Virginia, under many different local appellations. It runs about fifteen miles east of, and nearly parallel to, the Blue Ridge.

The first thing that strikes the observer in this district is the very gently undulating character of the surface, which is so marked as to arrest the attention of the non-scientific, and to induce speculation as to the causes producing it. The country from the Catoctin eastward to the Tertiary, is a gently undulating plain, descending from about 500 feet in elevation to the level of tide. Unlike the country near the Blue Ridge, and farther west, the topography is almost uninfluenced by the structure and composition of the underlying rocks. In the area in question we have strata showing all gradations of hardness, with all degrees of proneness to decomposition, and dipping at various angles, often steeply, yet all are planed down to a uniform level. The streams, except the smallest creeks, cross the strike of the strata nearly at right angles, and are hardly at all

guided or controlled in their courses by variations in the rocks across which they flow. They seem to be steadily deepening their channels, which work they have continued to perform, as it would seem, without noteworthy pause since their courses were first marked out.

The absence of any considerable inequality on the surface is well shown along the line of the Chesapeake and Ohio railroad, which runs between Richmond and Gordonsville, for fifty miles, directly across the strike of the various strata. In the area now in question the grades of the road are gentle, yet it turns aside for no hill, and has only one or two cuts which reach the depth of fifteen feet. Between the rivers, the country roads running east and west, pass over an almost uniformly level surface, of greater or less width, according to the distance apart of the principal streams. They are often almost devoid of water, as the smaller creeks rise in these levels, and flow north and south into the principal streams. There are many evidences showing that the level areas between the main streams are remnants of the original plane to which the country was cut down, and that the topography is entirely due to the action of the present system of streams in cutting down from this initial plane. Thus we find in the hill tops, and over the broader levels, certain clays and cobbles which occupy the same horizon always, and serve to fix the plane of this old surface. While peculiarities of erosion are shown in the character of some of the strata of the older Mesozoic belts, yet the principal denudation, and the most abnormal action, appear in the formation, and at the close of the deposit of the latest formed beds.

The condition of the surface of the Azoic rocks is also instructive. Those which admit of the formation and retention of smoothed and rounded forms, usually present such appearances. This is notably true of the granites and gneisses in the vicinity of Richmond.

The depth to which decay has penetrated here is far less than in the southern and southwestern parts of the State. In the latter we find strata not specially prone to decay, often decomposed, and changed to a loose earth, for fifty and even one hundred feet. This loose matter is suggestive of the way in which some of the later formed Mesozoic beds may have obtained their material, and its peculiar arrangement. This will be noticed later.

In the area of the Azoic with which we are now concerned however, the case is different. We rarely find the rocks decayed to as much as twenty feet in depth. Very often the surface clays rest on sound rock, or on that which is decomposed but a few feet below the surface. Again this decay has in nearly all cases taken place since the erosion above mentioned. We often

find, resting on such decayed surfaces, large stones and gravel deposited at this period of general erosion, which shows that the decay could not have existed when these stones were deposited. All the facts point to the conclusion that in this northern Azoic belt, the agent which produced such extensive general denudation found, it is true, the Azoic deeply decomposed, and having its surface in the condition now found in the southern and southwestern part of the State, but it swept off all this loose granitic matter, and even reached the sound rock in many places. We may now turn to the consideration of some of the special features shown in the different belts.

The New Jersey Belt.—Of this I shall have little to say, except to call attention to certain remarkable deposits of stones on its western margin. The deposits of similar matter in the northern exposures of this belt are called conglomerates, and sometimes breccias. For the beds in Virginia these terms are inadequate. They are rather beds of bowlders. The northwest dip of the Mesozoic beds with which they are associated, and their position on the western side of the belt, show that if these deposits are contemporaneous with the other Mesozoic strata, they are the last formed. But in some cases at least it is not clear that the period of their deposition followed immediately that of the typical Mesozoic beds. These stones are found in unconnected deposits on the western edge of all the interior belts. In all these locations we find essentially the same features, the close agreement of which indicates that they are of the same or nearly the same age. In character these beds of stone differ much from the normal Mesozoic strata with which they are associated. These latter consist of sandstones and shales, well sorted and bedded by water action, and with their mineral constituents too much decomposed to betray, except in rare cases, the parent rocks. The case is different with the stones in question. They are of such large size, and the material is so fresh, that there is no difficulty in determining the precise character of the rock from which they were derived. Indeed the material is often as sound as if it had been taken from a quarry freshly opened. The material in nearly every case comes from rock found in place at a greater or less distance to the west. This distance is often many miles. The stones are usually imperfectly rounded, or subangular. They are packed in a fine, more or less argillaceous matrix, derived either from the erosion of the normal Mesozoic beds with which they are associated, or from comminution of their own substance. These deposits are often sharply distinct from the associated normal Mesozoic beds, and appear as if deposited in depressions in them excavated by erosion. But again they appear sometimes alternating with shales, and thus to form strata contemporaneous with the nor-

mal ones. The most common matrix enclosing the stones is red shale.

The most important, and by far the longest uninterrupted bed of stones, is that known under the name of the "Potomac Marble," or the "Limestone Breccia." This enters the State near Point of Rocks, Maryland. At Point of Rocks it is well exposed by the cuttings for the Metropolitan Branch of the Baltimore and Ohio Railroad. I examined the deposit at this place carefully to determine the character and origin of the stones. The stones here are all limestone. After long and careful search I found only one fragment not limestone. This was a slab about eighteen inches wide and four inches thick, of apparently Potsdam sandstone. In this vicinity the Azoic rocks are mica slates. Azoic limestone occurs some distance to the northeast, and may have furnished an impure pinkish limestone, which ranks third in the abundance and size of the fragments it has afforded. These are rarely over six inches in diameter and usually are under this size. The most abundant stones come from the dark bluish limestones of the Lower Silurian, which are not found south of Pennsylvania. This limestone gives fragments sometimes two feet, and often twelve or eighteen inches in diameter. A white marble which is highly siliceous, and shows on weathered surfaces a sandy character, is the second in abundance and in the size of the fragments, which are sometimes a foot in diameter. These stones are when large, subangular, when small, partially rounded. They are cemented by a fine grained red shale, apparently eroded from the adjoining normal Mesozoic red beds. This is rendered highly calcareous by an intimate mixture of it with finely comminuted limestone. The stones are firmly cemented by this, and the whole lies in massive ledges having apparently a northwest dip. This may however be only a false bedding. This formation, here about half a mile wide, extends far into Virginia, with a predominance of limestone fragments. Professor Rogers has shown that it extends unbroken as far as Warrenton, with a constantly diminishing amount of limestone. As this limestone must have come from Maryland and Pennsylvania, we see that some of the stones must have traveled long distances, viz: forty or fifty miles. The predominance of limestone is marked for some distance south of Leesburg.

A second deposit, not connected with the last, is well shown near Culpepper Court House, where I made a careful examination of it. This does not show any stratification, or limestone fragments, but consists of a mass of partly rounded and subangular stones, usually perfectly sound, and all packed in a fine-grained red shale, which binds the whole into an exceedingly firm and durable rock. The stones are composed of the char-

acteristic rocks of the Blue Ridge, some twenty or twenty-five miles to the west, and northwest. They are commonly composed of a tough epidotic schist, subangular blocks of which, two feet by eighteen inches, and two feet by two and one-half, sometimes occur. The most abundant material is a compact chloritic schist which yields subangular stones two feet in diameter. By far the most common size, however, of all the stones, is from six to eight inches. Rocks yielding this material may be found nearer than the Blue Ridge, though none were seen in the immediate vicinity. Similar deposits are found at various other points on the west side of this, and the other interior belts. I will mention only one more, for the sake of illustration, and this occurs in the—

Pittsylvania Belt.—This deposit is remarkable for the great size and soundness of the stones, and for the complete contrast that it presents with the normal Mesozoic strata with which it is associated. These latter are here fine-grained red shales, dipping pretty steeply northwest. On the western edge of these, and apparently lying in a trough excavated by erosion in them, we find on George's Creek the bed in question. This was mentioned by Professor Rogers, on account of the large size of the stones. I made a careful examination of it. The most abundant and largest stones are composed of a coarse grained gneiss, which occurs in masses, sometimes hardly at all abraded, and up to four and five feet in diameter. Very commonly they are two and three feet in diameter. A fine-grained granite yields masses three and four feet in diameter, which show more abrasion. These occur with other material, all enclosed in a matrix composed of red shale, eroded from the normal Mesozoic, mingled with comminuted material similar to the large stones. All the large stones are remarkably fresh, and the whole mass is totally unlike anything seen elsewhere in this belt. The parent rocks yielding the stones may exist in the vicinity, though none exactly similar were seen in place. The normal strata of this belt may be divided into two series. The lower one contains predominant red and variegated shales, and red or brown sandstones. The sandstones often contain numerous, more or less angular, particles up to an inch or two in diameter, of the adjoining Azoic rocks, and commonly give evidence of rapid erosion and deposition. There is one very remarkable sandstone near the top of this series, which is composed almost entirely of feldspar. It consists of numerous partly rounded and slightly decayed particles of feldspar, with many perfectly fresh fragments of the same, showing brilliant cleavage faces. These are cemented by a felsitic paste into a firm rock, which can only by close inspection be distinguished from granite. It is difficult to see how

such a rock could have been formed out of any of the Azoic rocks in the vicinity, for these contain a good deal of quartz, even when richest in feldspar, and this sandstone contains very little.

The upper series contains a predominance of reddish and dark bituminous shales and gray grits. Only faint traces of coal exist, in the form of thin films. No plant impressions were seen but some silicified wood occurs. The dip is northwest over the whole belt, varying from thirty to forty degrees. This constant high dip indicates a thickness for the formation which is not justified by the other indications. In the description of the Richmond coal field I will state what I think is the explanation of this apparent anomaly.

Deposits of bowlders similar to those above described appear, according to the statements of Emmons and Kerr, to be found associated with the Mesozoic of North Carolina. Emmons mentions beds of large stones as found on the west side of the Dan River coal field. There the normal strata dip northwest. Kerr mentions similar beds as occurring on the east side of the Deep River coal field, where the normal strata dip southeast. He however thinks that these stones come from the Azoic on the east, and attributes their transport to a pre-Triassic glaciation. I do not understand on what grounds Professor Kerr thinks that these beds are pre-Triassic, as he does not indicate any change of dip in the associated normal beds. This southeast dip and the position of the beds, would indicate that they are, as in Virginia, post-Triassic. Professor Emmons mentions that the Egypt shaft after passing through twenty-eight feet of soil (?) penetrated two feet of large stones, resting on the coal shales. This may be the same deposit with that of Professor Kerr. It does not seem possible that water action alone could have deposited these stones in their present position. For if we could conceive of a torrent of such power as to be able to transport these masses, and which would at the same time not remove the fine matrix in which they are imbedded, we should still be unable to understand how water could reach and remove material which had never been exposed, as surface rock, to the decomposing action of atmospheric agencies.

I will pass over the Buckingham Belt and the Prince Edward Belt, as I had no opportunity to study them, and will consider next the—

Richmond Coal Field.—This portion of the Richmond Belt, which, as previously defined, lies south of the Chickahominy River, is the only Mesozoic area in Virginia which shows the structure of a basin. The strata may be divided into two series, which show, as a whole, very marked differences, but between which no distinct line of separation can be traced.

The lower series, from three hundred to five hundred feet thick, rests immediately on the granitoid gneiss, which forms the floor of the basin. It contains all the coal found in the field. The number of coal beds is variable, but the most important are usually two or three in number, all contained within the space of about one hundred feet, and the lowest lying near the floor. In placing this coal-bearing portion next to the granite, I follow Rogers and Lyell, as their observations, which were more extensive than my own, show that the interval between the lowest coal beds and the granite is quite variable. The associated strata are usually flaggy sandstones, and more or less indurated shales, the material of all being so thoroughly sorted by water action and so completely changed that the parent rock cannot be recognized. The beds give proof of a good deal of disturbance in the presence of "slickensides," contortion, crushing and induration. Faults affect both this and the upper series, and suddenly collapsed anticlinals of small width occur, so that the dip is quite variable. As a rule the dip on the eastern side is westward and on the western side eastward, being steeper on the latter side, and the strata sometimes attain here a perpendicular position.

The upper series is perhaps not more than fifteen hundred feet thick, and differs in many points from the lower. The strata are mainly sandstones, sometimes coarse and conglomeratic, and as Rogers has shown, possessing the peculiar composition of a mixture of feldspar, quartz and mica, unsorted, and but little decomposed. They form a sort of granitic grit, which causes the rock to resemble granite. Subordinate beds of shale exist. This series shows less disturbance than the lower. The dip is more gentle, the beds are but little consolidated, or affected by crushing and rubbing. It contains no coal, and none except drifted, poorly preserved plants. The entire upper series shows marks of having been deposited in a rapidly sinking area, into which was poured an abundance of coarse matter, obtained by the rapid erosion of the surrounding granitoid rocks.

It is clear that much of the disturbance shown by the lower beds occurred during this sinking, which has also affected them with steeper dips than are found in the upper series. The lower beds were evidently deposited slowly, on a pretty stable area, which remained at the same level long enough for the important coal beds now found to be formed. The subsequent sinking seems to have been too rapid to permit the growth of sufficient vegetation to produce coal. Both series are penetrated by dykes of igneous rock. The rolls in the strata and the faults affect the structure of the field to such an extent that it is difficult to determine its depth, and determinations from shafts and borings cannot be relied upon absolutely. To

illustrate this, I may mention two cases. Lyell states that the Midlothian (old) shaft was sunk within the field to the west of the previous workings, and entered the coal three hundred feet higher than was expected from the dip, thus giving an upthrow of this amount. This is on the east side of the field. On the west side at the Dover Mines, the company owning the works attempted to develop a new portion of the field by sinking a shaft a few hundred yards to the east of their old workings. They penetrated the entire series of strata, and found nothing workable.

My examination of some of the finger-like remnants of the Mesozoic, now found at the northern end of this field, thrust out in the Azoic, put me in possession of what I think is the explanation of the peculiarities of the structure of this field, and of the interior belts. The history of these areas, briefly stated, seems to be as follows:—

The strata were laid down in depressions, which, originally shallow, were subsequently deepened by a more or less rapid subsidence. The subsidence was due, as previously stated, to the operation of a lateral thrust. It continued until faults and overturned anticlinals were produced. In the interior belts these operated to produce a constant northwest dip. This resulted from the fact that the western sides of the severed earth prisms dropped, producing sometimes by a roll of the prisms an upthrow of the eastern side. This appears to occur in some of the faults of the Richmond coal field also. When the strain did not result in producing rupture and faulting, it caused the development of an anticlinal, affecting but a narrow belt, which was overturned to the eastward, thus producing also a continuous northwest dip. Where the strata have suffered enormously from erosion, and where almost precisely similar beds are formed by the similar conditions of deposition found repeated at different horizons, as is often the case in the interior belts, it is almost impossible to detect reduplications by faulting and folding. When the period of faulting was reached, eruptions of trap took place. It will thus be seen that the continuous dips would by no means give a true indication of the thickness of the series.

In the Richmond coal field the faults and narrow overturned folds are not of sufficient magnitude to produce, as in the interior belts, continuous dips, but suffice only to render very variable and uncertain the dip and position of the strata toward the center of the field. The general result seems to have been to flatten the dip here, and to steepen it on the western side. Some of the twists in the strata, produced by the overturned anticlinals, are of extremely limited extent. I have seen them only a few feet wide.

The direction, in which the lateral thrust operated in this field, was from east to west, and it seems not yet to be exhausted, for this region is often affected by minor earthquakes, and at intervals of ten or fifteen years, by very powerful ones, the last occurring a few years ago. The shocks pass from east to west. It is probable that the gradual depression of the coast is connected with this westward thrust.

Fossil Plants.—So far as known to me, the only plants from this field which have been published and described, are those made known by Rogers and Bunbury. Both of these authors considered the plants to be of the age of the lower Oolite of England. Most geologists, however, seem to agree in considering the beds yielding the plants, to be of the age of the Keuper, or Upper Trias. It must be borne in mind that only the lower, or coal-bearing portion, has yielded these plants.

Among European authors, Heer and Schimper are the only ones who, so far as I know, express an opinion concerning the age of the beds, based on an examination of the plants. I have not seen Heer's remarks, and hence do not know on what grounds he concludes that the plants are Triassic. Schimper, on page 277, vol. i, of his Pal. Veg., founds his belief in the Triassic age of the beds yielding the plants, both on the animal and plant life. I will consider only the latter.

He says, in speaking of the characteristic Equisetum of this field, which he calls *Equisetum Rogersii*, that it is nearer to *E. arenaceum*, the characteristic Equisetum of the Trias, than to *E. columnare*, the plant of the Lower Oolite with which Rogers and Bunbury thought it to be identical. He, however, only saw a cast of the interior of the Richmond plant. He says, farther, that this coal field has Pterophylla and Ferns, which have most affinity with the characteristic species of the Keuper. It does not appear from what source he derived this impression.

He is mistaken both concerning the Equisetum, and the other plants from this field. This Equisetum is next to *Macrotæniopteris grandifolia*, the most abundant and widely diffused plant of the field. I have beautifully preserved specimens, on a fine-grained shale, which shows with the utmost nicety the minutest details of the exterior of the plant. It is certainly so close to *Equisetum columnare* that, if separated, it can only be made, at most, a variety. The most abundant, widely diffused and characteristic plant, is *Macrotæniopteris grandifolia*, described by Rogers as *Tæniopteris grandifolia*. It is a curious illustration of the confusion existing in the minds of European writers concerning this coal field, to find that Schimper, in speaking of this plant, refers it to the *Oolitic* beds of the Richmond coal field, while he refers its constant companion, the Equiestum above mentioned, to the Keuper of the Richmond field. The

fact is, that when both of these plants occur at a locality, they are so closely associated that they are confined to the same layer, from which they seem to exclude nearly all other species. Schimper also refers to the Oolite of the Richmond coal field, another plant often found associated with these two, viz: *Neuropteris linnæifolia* Bunb.

The *Macrotæniopteris* is allied more closely to the Oolitic *Macrotæniopterids* of England and India, than to any older plants. The nearest to it, among older plants, is the *Tæniopteris gigantea* Schenk, of the Rhætic. Nothing like it exists in the Trias. The *Pterophylla* of the Richmond beds belong to the Rhætic type, illustrated by *Pterophyllum Braunianum*, which type Schimper separates under the name of *Ctenophyllum*. These plants are very different from the Keuper type of true *Pterophylla*, as shown in *P. Jägeri* and *P. longifolium*. The plant which stands third in distribution and abundance, is one which I cannot distinguish from *Pterophyllum Braunianum*, which is a characteristic Rhætic plant, as given by Schenk.

The Ferns are either similar to Rhætic forms, or have an affinity with still later ones. I have fine specimens of a splendid Fern, which is allied to *Cyclopteris pachyrachis* Gœpp., though it is a smaller plant, and is a new species. From its association with *Neuropteris linnæifolia* Bunb., and the resemblance of the two, I think that it is the male form of Bunbury's plant. They are both allied to *Acrostichites Gœppertianus* Schenk, which is a Rhætic plant. I have also specimens of a fine Fern, closely allied to, if not identical with, *Asplenites Rösserti* Schenk, which is a characteristic plant of the Rhætic. Others might be mentioned, which show either Rhætic or Liassic, and even Oolitic affinities. I have not seen in this field a single Triassic plant.

In the revised edition of Dana's Manual, *Pecopteris* (*Lepidopteris*) *Stuttgartensis* Brongt., is given as occurring in this field. This statement is probably based on the identification by Heer, of this plant with Bunbury's *Pecopteris bullata*. I have seen nothing like *Pecopteris Stuttgartensis* in this field, but I have a number of fine specimens of a large Fern, which I take to be Bunbury's *P. bullata*. If they are not, then I have not seen this plant, though I have collected from the localities yielding it. My specimens show more of the character of the plant than Bunbury's, which, as is known, were very imperfect. It is certainly not *Pecopteris Stuttgartensis*. I have devoted more space to these Richmond plants than I would otherwise have done, because this flora is the oldest* of the Mesozoic of Virginia, and serves as a point of comparison for the plants found

* By this I do not mean that the beds containing this flora are the oldest of the Mesozoic strata in Virginia. The lowest strata of the interior belts have much in common, and are all, I think, Triassic. This is the oldest flora yet discovered.

in the other belts. These plants all come from the lower series. As the result of my preliminary study of them, I conclude that the lower series is certainly not older than Rhætic, and if it be not Rhætic, then it is younger. Some may question the separation of the Rhætic from the Triassic. Whatever may be the evidence of the animal life of these two formations, the plants are different, and the Rhætic flora is rather to be reckoned with the Liassic than the Triassic flora. Schimper, Heer and Schenk, all show that the Rhætic flora contains no Triassic species.

[To be continued.]

ART. III.—*Discoveries of the United States Fish Commission: Notices of fifty species of east-coast Fishes, many of which are new to the fauna;* by G. BROWN GOODE and TARLETON H. BEAN.

THE object of the present paper is to give a brief summary of the coast investigations of the United States Fish Commission (Professor S. F. Baird, Commissioner) since the publication of a similar paper in this Journal for December, 1877, pp. 470–478. Certain species which should be mentioned here have not yet been identified; these will be reserved for a future paper. Full descriptions of species and discussions of questions hinted at in these notices have appeared or will appear in the Proceedings of the United States National Museum.

1. *Chilomycterus fuliginosus* (DeKay) Gill.

This species had been dropped by common consent from the faunal list; but after careful study of a specimen seined on Watch Hill beach, Rhode Island, September 12, 1874, we feel compelled to restore it.

2. *Hippocampus antiquorum* Leach.

Taken with a school of mackerel on George's Bank, August, 1873.—An addition to the fauna of the Western Atlantic.

3. *Glyptocephalus cynoglossus* (Linné) Gill.

The craig flounder abounds in deep water off the coast from Cape Ann to Halifax, occurring at a depth of thirty-five fathoms in Ipswich Bay, Massachusetts, and in Bedford Basin, Halifax Harbor, and seaward to a depth of 111 fathoms. Careful study of a large series of specimens has enabled us to unite with this species *Glyptocephalus acadianus* Gill and *Pleuronectes elongatus* Yarrell.

4. *Hippoglossoides limandoides* (Bloch) Günther.

Hippoglossoides dentatus (Storer) Günther, is apparently identical with this European species. The genus *Pomatopsetta* Gill,

which was founded on Storer's *Pleuronectes dentata*, has no characters by which it may be distinguished from *Hippoglossoides*, and it should be set aside. *Hippoglossoides limandoides* is a deep water species found constantly with the preceding.

5. ***Pleuronectes glaber*** (Storer) Gill.

As a rule, the female may be distinguished from the male by its smooth scales, especially in the breeding season, and by its greater size. Gravid females were received from Salem, Massachusetts, January 10, 1878. The eggs are one-thirtieth of an inch in diameter. (Bean.)

6. ***Ancylopsetta quadrocellata*** Gill.

Of this species, which was described from Pensacola, Florida, and not elsewhere recorded, Professor S. F. Baird obtained two specimens in Charleston Market, South Carolina, April, 1877.

7. ***Reinhardtius hippoglossoides*** (Walb.) Gill.

The southern range of this Arctic species has been extended to latitude 42° N. Fishermen take them frequently in the gully between Le Have and George's Banks, at depths greater than 200 fathoms. They appear to inhabit the abrupt oceanic slopes of the banks beyond and below the range of the halibut; this fact, together with the uniform dark coloration of the under side of the body, seems to indicate that its habits differ from those of other pleuronectoid fishes.

8. ***Chænopsetta oblonga*** (Mitch.) Gill.

One specimen was trawled August 15, 1878, in the harbor of Gloucester. It has not previously been recorded in Massachusetts Bay except at Provincetown, where Captain Atwood obtained it in 1846, and where it has since been occasionally observed.

9. ***Macrurus Bairdii*** Goode and Bean.

The unique specimen of this species has been supplemented by three additional ones captured August 27, 1878, forty-two miles off Eastern Point Light (Cape Ann), E. $\frac{3}{4}$ S., in 175 fathoms, which is within two or three miles of the locality at which the type was secured.

10. ***Macrurus rupestris*** Bloch.

Many specimens have been brought in by fishermen whose testimony is that it is abundant in the deep waters on George's and the more northern banks.

11. ***Phycis Chesteri*** Goode and Bean.

Three specimens of a new species of *Phycis* were caught in the trawl-net thirty-three to forty-two miles E. by S. from Cape Ann in 110 to 140 fathoms. The largest measured

0·242^{m} (without caudal), the others 0·143^{m} and 0·142^{m}: the latter were immature, and with the specific characteristics, particularly the length of the fin rays, not fully exhibited. The species may be characterized as follows. Head contained in length of body (without caudal) four and one-third times. Height of body in length five times. Diameter of orbit in length of head three and a half times, length of maxillary twice. Barbel one-third diameter of orbit. Vent in vertical from twelfth ray of second dorsal, and equidistant from tip of snout and extremity of second dorsal. Distance of first dorsal from snout equal to twice the length of mandible. Third ray of dorsal extremely elongate, extending to the thirty-third ray of second dorsal and two-thirds of the distance from snout to tip of caudal, its length more than twice that of the head. Anal inserted immediately behind the vent, at a distance from the ventrals equal to that of dorsal from snout. Ventral composed of three rays,* the first and second much prolonged, the first almost one-third as long as the body, the second three times as long as the head, extending to the fortieth ray of the anal fin and to a point three-fourths of the distance from snout to tip of caudal; the third shorter than the diameter of the orbit. Pectoral four times as long as the operculum. Scales large and thin, easily wrinkling with the folding of the thick flabby skin. Lateral line much broken on the posterior half of the body. Scales in ninety to ninety-one vertical rows and thirty-five horizontal rows, of which seven are above the lateral line. Radial formula: D., 9 or 10, 55 to 57. A. 56, C. 5, 18 to 21, 5. P. 17 or 18, V. 3.

The species has been named in honor of Captain H. C. Chester, well known as an Arctic explorer, and for four years attached to the United States Fish Commission.

12. ***Haloporphyrus viola*** **Goode and Bean.**

Two specimens of an undescribed species of the genus *Haloporphyrus* of Günther were brought in August 24, 1878, by Captain Joseph W. Collins of the schooner "Marion." They were taken on a halibut trawl-line on the outer edge of Le Have Bank at a depth of four or five hundred fathoms. The species may be briefly characterized as follows:

The head is contained four and one-third times in total length without caudal. The diameter of the orbit is one-fourth of the length of the head, or slightly more. The maxillary extends

* A critical study of the ventral fins of *Physcis* leads us to believe that one of the accepted characters of the genus and of the sub-family *Phycinæ* is false, there being three separately articulated rays in each ventral. In the young of *Physcis chuss*, for instance, the short third ray is apparent, but in the adult it is hidden in the thick skin which envelopes the bases of the first and second rays, causing them to appear like "a single long ray bifid at the end."

to the vertical from the posterior margin of the orbit. The barbel scarcely equals half the diameter of the orbit.

The vent is situated under the nineteenth ray of the second dorsal, equidistant from snout and tip of caudal.

The anal is inserted behind the vent at a distance equal to the length of the second anal ray; it has a considerable depression in its middle and terminates in a line with the end of the second dorsal.

The pectoral is slightly more than four fifths as long as the head and extends to the vertical from the ninth ray of the second dorsal. Its length equals greatest height of body.

The longest ray of the ventral is about seven-eighths of the length of the head, and extends half way to the vent.

Radial formula: D. 4, 53; A. 40; V. 6. Scales in lateral line about 115; above lateral line 11.

13. *Hypsiptera argentea* Günther.

A single individual was taken at the surface, May, 1878, about forty miles off Cape May, New Jersey, by Captain Robert H. Hurlbert of Gloucester. This is an addition to the fauna of the Western Atlantic.

14. *Lota maculosa* (Le Sueur) Richardson.

After close study of a large series of specimens representing every locality from which species of *Lota* have been described in America and many places in Europe, Dr. Bean agrees with late writers in referring all the American species, so called, to *Lota maculosa*. This species, in the skeletons examined, has sixty-four vertebræ. The European variety, in two examples studied, shows sixty-one vertebræ. Dr. Günther gives the number as sixty. On the basis of this difference in the number of vertebræ Dr. Bean, for the present, separates the European from the American burbot as a variety with the name *Lota maculosa* (LeSueur) Rich. var. *vulgaris* Jenyns. Further observation of the number of vertebræ is very desirable.

The specific name *maculosa*, formed by Le Sueur in 1817, seems to have priority. Walbaum's *Gadus lacustris* was evidently a catfish.*

The name *vulgaris*, though attributed to Cuvier and Jurine was not used nor claimed until in 1835 by Jenyns in his Manual of the Vertebrate Animals.

15. *Lycodes Verrillii* Goode and Bean.

Taken sparingly in from 73 to 114 fathoms off Cape Ann, at one time within seven miles of Thatcher's Island.

* See the description and also "Mathemeg" in Rich. Faun. Bor. Amer., p. 135, and Jordan, Bull. x, U. S. Nat. Mus., p. 84.

Professor Robert Collet* has considered this species identical with his *L. Sarsii;* but even the comparative tables which he introduces in support of this position show that the two species are clearly distinct.

16. *Leptoblennius serpentinus* (Storer) Gill.

Taken occasionally in seventy fathoms or more.

17. *Anarrhichas lupus* L.

Specimens of an *Anarrhichas* with brown cross bars instead of spots and which cannot in any way be distinguished from the European species, have been taken during the past season. We add this species to the faunal list without expressing an opinion as to the validity of the species *A. vomerinus* Agassiz.

18. *Eumicrotremus spinosus* (Fabr.) Gill.

Three specimens were secured, September 2, 1878, seventeen and three-quarter miles S. E. ½ E. from Eastern Point Light, Cape Ann, in twenty-three to twenty-eight fathoms.

19. *Trichidion octonemus* (Girard) Gill.

Of this species, hitherto known only from Texas, the United States National Museum has lately received a specimen collected by Mr. Silas Stearns at Pensacola, Florida.

20. *Orcynus pelamys* (Linné) Poey.

A specimen of the oceanic bonito was taken in July or August, 1877, off Provincetown, Massachusetts, and presented by Mr. Jas. H. Blake to the Museum of Comparative Zoology. An addition to our fauna.

21. *Caulolatilus microps* Goode and Bean.

A specimen two feet three inches in length, taken March 18, 1878, on the Snapper Bank, off Pensacola, Florida, in thirty-five fathoms of water, was received from Mr. Silas Stearns. For a full description see Proc. U. S. National Museum, 1878, p. 42.

22. *Cynoscion regalis* (Bloch) Gill.

Three individuals have been taken during the summer in Capt. Webb's trap near Thatcher's Island, off Cape Ann. It had not previously been recorded farther north than Provincetown, Massachusetts.

23. *Menticirrus nebulosus* (Mitch.) Gill.

One specimen was secured in the summer of 1878 by Captain Webb in the trap just referred to. Provincetown has been heretofore its recorded northern limit.

*Fiske fra den norske Nordhavs—Exped. 1876–77, Christiania Vidensk.—Selsk. Forhandl. 1878, No. 4.

24. *Stenotomus argyrops* (Linné) Gill.

The northern range of the scup is extended to Thatcher's Island, off Cape Ann, where it has recently been taken in considerable numbers by Captain Webb.

25. *Sargus Holbrookii* Bean.

Six specimens of this new species, from Savannah Bank, were sent to the United States National Museum, March 29, 1878, by Mr. Goode. Numerous individuals apparently belonging to the same species were collected at Beaufort, North Carolina, by Professor D. S. Jordan during the summer of 1878.

Diagnosis: Body ovate, compressed, a very slight protuberance above the upper anterior margin of the orbit, and a very marked one in the supra-occipital region. Distance from origin of ventral to origin of spinous dorsal is about two-fifths of total length to end of middle caudal rays.* Least height of tail is about equal to length of upper jaw.

Length of head is contained three and three-quarter times in total. The interorbital area is slightly less than one and a half times the long diameter of eye. The length of snout is one-tenth of total length and about equals that of mandible. The eye is contained nearly four and one-fifth times in length of head.

The longest dorsal spine is contained from eight and one-half to ten times in total length of body.

The distance of anal from snout is contained one and five-eighth times in total length. Longest anal spine equals one-twelfth of total length.

The length of middle caudal rays equals that of snout.

The distance of pectoral from snout is contained three and one-half times, and its length about three times in total length.

The distance of ventral from snout slightly exceeds the length of pectoral. Length of ventral averages nearly one-fifth of total length.

Radial formula: B. vi; D. xii, 13–14; A. iii, 13–14; P. 15–16; v, 1, 5.

Scales: 8–60 to 62–16.

Teeth: eight incisors in each jaw, their greatest width equal to half their length. Three rows of molars above, two below, with sometimes a tendency to increase the number of rows.

For a full description, see Proc. U. S. National Museum, 1878.

26. *Rhomboplites aurorubens* (Cuv. and Val.) Gill.

A specimen of this species, hitherto known only from the West Indies was secured in May from Mr. C. C. Lesley, of

* This length is the basis of comparison for all my measurements of this species.

Charleston, South Carolina, another was collected at Pensacola, Florida, by Mr. Silas Stearns a few days later.

27. *Lutjanus Blackfordii* Goode and Bean.

The "red-snapper" of the Southern Atlantic and Gulf coasts proves to be distinct from the West Indian species with which it had previously been confused. It was named in honor of Mr. E. G. Blackford of New York City, a gentleman who has rendered many important services to American ichthyology. Full descriptions of this and the following species may be found in the Proceedings of the U. S. National Museum.

28. *Lutjanus Stearnsii* Goode and Bean.

The "mangrove snapper" of the Gulf of Mexico proved to be new and was named in honor of Mr. Silas Stearns of Pensacola, by whom the only known specimen was collected. *Rhomboplites aurorubens*, mentioned above, is known at Charleston as the "mangrove snapper," at Pensacola as the "bastard snapper."

29. *Epinephelus Drummond-Hayi* Goode and Bean.

This magnificent species was first discovered at the Bermudas in 1851, by Col. H. M. Drummond Hay, C.M.Z.S., by whom a sketch and partial description were prepared. The National Museum has lately received two specimens from Florida, one from Mr. Blackford, collected at the Keys, the other from Mr. Stearns at Pensacola. The species attains the weight of fifty pounds or more.

30. *Epinephelus niveatus* (Cuv. and Val.) Poey.

This species has been taken twice at Newport, Rhode Island, by Samuel Powel, Esq. The first specimen, a young individual, was made the type of the genus *Hyporthodus** by Professor Gill. A comparison of *Hyporthodus flavicauda* Gill with Cuban specimens of *Epinephelus niveatus* proves their identity. The second specimen was received from Newport in 1877. It has not been recorded elsewhere on the East coast.

31. *Roccus lineatus* (Bl. Schn.) Gill.

The "rock-fish" is taken in winter in the Altamaha River, in considerable numbers. South of this region its occurrence is extremely rare. Two were observed in the St. Johns River, Florida, in 1874; and in May, 1878, a stray individual was sent by Mr. Stearns from Pensacola.

32. *Remoropsis brachyptera* (Lowe) Gill.

Two specimens of this rare species have been obtained from fishing schooners. One was found clinging to the side of a

* Proc. Acad. Nat. Sci. Philad., 1861, pp. 98–99.

sword-fish harpooned in the channel southwest of George's Bank, another on the deck of a halibut-trawler fishing in the gully northeast of George's Bank, at a time when sword fish were being taken on the trawls. This species may very probably be a parasite peculiar to *Xiphias*, as the allied species, *Rhombochirus osteochir* is to *Tetrapturus albridus*.

33. ***Belone latimanus*** Poey.

The occurrence of a single specimen of this West Indian form in Buzzard's Bay, where it was obtained by the Commission in 1875, has already been recorded (Proc. U. S. National Museum, i, 1878, p. 6.) Several additional specimens from North Carolina or Chesapeake Bay, were obtained in Fulton market, New York, June 1, 1878.

34. ***Belone hians*** Cuvier and Valenciennes.

In company with the preceding were several specimens of this species hitherto recorded only from Bahia, the West Indies, and the Bermudas.

35. ***Fundulus seminolis*** Lesueur.

This species, long lost sight of, was collected in quantity by Professor Baird on the upper St. Johns River.

36. ***Lucania parva*** (Baird and Girard) Bean.

The *Cyprinodon parvus* of Baird and Girard should be referred to the genus *Lucania* Girard. The species is recorded only from Beesley's Point, New Jersey, Sinepuxent Bay, Maryland, Greenport, Long Island and Noank, Connecticut. (Bean.)

37. ***Alepidosaurus ferox*** Lowe.

Six specimens of this species are now on record in the United States—one in the collection of the Boston Society of Natural History and five in the United States National Museum. All of these have been captured within the limits of lat. 41° and 44° and at depths of 200 to 400 fathoms.

The first capture of *Alepidosaurus* in the Western Atlantic, was by Captain D. C. Murphy of the schooner Centennial in July, 1877, in 200 to 300 fathoms. Lat. 43° 46′ N.; long. 59° 19′ W.

38. ***Salmo salar*** L.

The salmon has been transported by the Commission of Fisheries to the rivers of the Middle States, to many points in the Mississippi valley and to the California coast. It may be regarded as acclimated in the Hudson, Delaware and Susquehanna Rivers, and re-acclimated in the Connecticut.

39. *Brevoortia tyrannus* (Latrobe) Goode.

The common menhaden was described under the name *Clupea tyrannus* by Latrobe in 1802, and the specific name then proposed has priority over all others. An extended study of the species of this group indicates that the *B. tyrannus* occurs on the coast of Brazil, as far south as Bahia, and that Spix's *Clupanodon aureus* is specifically identical and should be included as a subspecies, *B. tyrannus* subspecies *aurea*.

40. *Brevoortia patronus* Goode.

A species occurring at several points on the north shore of the Gulf of Mexico, from the mouth of the Rio Grande to Pensacola, Florida, where Mr. Stearns observed it in great abundance.

41. *Alosa sapidissima* (Wilson) Storer.

Through the agency of the United States Commission of Fisheries the common shad has been introduced into most of the rivers flowing through the Southern States into the Gulf of Mexico, and may now be considered a member of the fauna of that region, its range south and west having been extended over at least twelve hundred additional miles of coast line. It is also acclimated in California.

42. *Pomolobus pseudoharengus* (Wilson) Gill.

Abundant in Lake Ontario, Cayuga and Seneca Lakes, New York. The variety *lacustris*, founded on Cayuga Lake specimens by Professor Jordan, is precisely like the average coast alewife. After careful measurements of numerous lake and coast specimens I am unable to separate them. (Bean.)

43. *Nemichthys scolopaceus?* Richardson.

A single specimen nineteen inches long, of a curious eel-like fish was obtained from a fisherman who took it, living, from the stomach of a cod fish caught on George's Bank in February, 1875, in forty-five fathoms. Another, preserved in the collection of the Cape Ann Literary and Scientific Association at Gloucester, was picked up on the deck of a cod vessel. It belongs to the genus *Nemichthys* described by Sir John Richardson from a specimen collected by the exploring ship Samarang in the South Atlantic. Only one species has been described, the type was from the South Atlantic. Another specimen of the genus was taken at Madeira and described by Lowe under the name *Leptorhyncus Leuchtenbergii*. Günther considers it to be identical with *N. scolopaceus*. The American fish is at present assigned to the same species. The family *Nemichthyidæ* is new to the Western Atlantic.

44. ***Amia calva*** **L.**

The range of the mud-fish has not hitherto been recognized to extend south of Charleston, South Carolina, whence Garden sent specimens to Linnæus. It occurs abundantly in the St. Johns River, Florida, and Mr. S. C. Clarke found it in Spruce Creek, a tributary of Halifax River, about lat. 28°.

45. ***Chimaera plumbea*** **Gill.**

Within the past twelve months seven individuals have been secured—one by the Boston Society of Natural History and six by the United States National Museum.

The first specimen was taken by Captain D. C. Murphy of the schooner Centennial in July, 1877, in 200 to 300 fathoms, lat. 43° 46′ N., long. 59° 19′ W. Others have since been taken within the latitudes 42° and 44° N. and in water from 200 to 350 fathoms deep.

46. ***Torpedo occidentalis*** **Storer.**

Taken occasionally near Thatcher's Island, off Cape Ann, by Captain Webb, in his trap. A specimen was taken at Lanesville, Massachusetts, July 13, 1878, the only instance of its occurrence to the northward of the point of Cape Ann.

47. ***Hypoprion longirostris*** **Poey.**

A West Indian species; collected in the Gulf of Mexico, by Dr. J. W. Velie, of Chicago, and sent to Washington for identification.

48. ***Centroscymnus cœlolepis*** **Bocage and Capello.**

This species was described from the coast of Portugal. It is recorded, also, from Madeira. Three specimens were presented to the United States National Museum, August 26, 1878, by the crew of the schooner Marion, who captured them on the Nova Scotia banks, the first specimens known from the Western Atlantic.

49. ***Centroscyllium Fabricii*** **(Reinh.) Müller and Henle.**

A Greenland species. One individual was received from Captain Jos. W. Collins, schooner Marion; locality same as the last. This species is new to the fauna of the Western Atlantic. Both this and the preceding are called by the fishermen "Black Dog fish."

50. ***Ginglymostoma cirratum*** **(L. Gm.) Müller and Henle.**

An adult specimen was taken in the Gulf of Mexico, by Dr. J. W. Velie of Chicago. A young individual was captured by Mr. Otto Lugger in Chesapeake Bay.

Gloucester, Mass., September 7, 1878.

ART. IV.—*Note on the Brightness and the Stellar Magnitude of the third Saturnian satellite*—Tethys; by EDWARD S. HOLDEN.

[Communicated by permission of Rear Admiral JOHN RODGERS, U. S. N., Superintendent U. S. Naval Observatory.]

ON November 20, 1878, I was observing *Saturn's* satellites with the 26-inch refractor, using an eye-piece magnifying 400 diameters. Four satellites were nearly in the plane of the ring (position angle 94°·2). They were

Tethys; $p=265°$,	$s=35''$; (estimated.)
Dione; $p=94$,	$s=60''$; (")
Titan; $p=94\pm$,	$s=$over $150''$ (estimated.)
Enceladus; $p=92$ (est),	$s=31''\cdot13$ (measured.)

At about $8^h\ 30^m$ as I had just completed the measure of the distance of *Enceladus*, the sky became covered with flying clouds, which continually passed over *Saturn*, partially obscuring the planet and dimming the light of the satellites. The clouds were probably forming and disappearing constantly, as the air was full of moisture, the difference of the wet and dry bulb thermometers being less than 1° F.

I had noticed before beginning to observe that large portions of the sky were alternately obscured and clear, evidently owing to thin clouds formed on the spot.

The disappearance or dimming was gradual and it seemed suited to a photometric experiment similar to that tried by Bond on the nebula of *Orion* during twilight, when the order of the appearance of the details, with the times, were noted.*

Accordingly, Mr. Anderson, assistant, watched *Saturn* with the naked eye, looking along the telescope as a guide at the planet, while I watched the appearance of the satellites through the equatorial. The interior of the dome was perfectly dark.

As a cloud gradually (and as nearly as could be judged uniformly) darkened *Saturn* as seen in the telescope, the appearances were carefully noted and when the planet disappeared to the naked eye Anderson called "now."

At this instant I endeavored to note the visibility of the satellites.

Enceladus, which was faint at the best, always disappeared before this instant. In four (tolerably satisfactory) experiments it was found that *Tethys* disappeared in the telescope at the same instant that *Saturn* did to the naked eye. In several reappearances I found that *Dione* reappeared in the telescope

* Annals Harv. Coll. Obs., vol. v, p. 164, etc.

just before *Saturn* appeared to the naked eye; and that *Tethys* was seen almost at the same time, or a very little after this. When *Saturn* was just appearing or disappearing *Titan* was as bright in the telescope as *Dione* when no clouds were present.

Dione was always a little brighter that *Tethys*. The southern edge of the belt in the southern hemisphere of *Saturn* vanished *about* at the same time as *Enceladus*. This observation is, however, not so precise as those on *Tethys*.

As many appearances and disappearances as possible were observed and the result of them all is that *Tethys* was as bright to my eye in the telescope as *Saturn* was to Anderson's unassisted eye. It may be mentioned that Anderson under good circumstances can see *Uranus* with the naked eye, and by experience I have learned that my eye is well suited to seeing faint satellites like those of *Uranus* and *Neptune*. I believe that our eyes used as in this experiment were as nearly equal as any could be.

The sky became totally cloudy before I could measure the the position of *Tethys*. From Prof. Newcomb's MS. tables the time of West elongation is $12^h.4$ Wash. m. t.

These experiments enable us to determine approximately, the relative brilliancy of *Tethys*, in this part of its orbit, with *Saturn*. Assuming the diameter of the pupil of the eye at $0{\cdot}2^{in}$ the relative amount of light received by Anderson's eye from *Saturn* and through the telescope from *Tethys* are as $(26{\cdot}00 \text{ inches})^2$ to $(0{\cdot}2 \text{ inches})^2$, or as 16,900 to 1. So that the immediate result of these experiments is that *Tethys* was at that time $\frac{1}{16900}$th part, or 0·00005917 as bright as *Saturn*, including both ball and ring.

From the table given by Zöllner in *Photometrische Untersuchungen*, p. 200, it follows that if *Saturn* had been without his ring, the light from the ball alone would have been 0·9356 (log. 9·9711) of the light of ball and rings combined. Hence if H_1 is the light from the ball alone, the light received from *Tethys* was $\frac{1}{16{,}900} \cdot \frac{H_1}{0{\cdot}9356} = 0{\cdot}00006323.\ H_1\ (\log.\ 5{\cdot}8009\ H_1)$.

If H_1 is the brilliancy of a planet at a time when its distance from the sun is r_1 and from the earth ρ_1; and if d is the true diameter of the planet in miles and A a constant depending on the nature of its reflecting surface then

$$H = A.d^2\left(\frac{1}{r_1^2.\rho_1^2}\right)^*$$

At another time, $H_2 = A.d^2.\left(\frac{1}{r_2^2.\rho_2^2}\right)$ and

$$H_1 : H_2 = r_2^2\,\rho_2^2 : r_1^2.\rho_1^2.$$

* See Stampfer: Sitzungsber. der k. Acad. d. Wiss. Berlin, vol. vii, 1851, p. 760.

For November 20, $8^h.5$ Wash. m. t., log. $r_1 = 0{\cdot}9787$ and log. $\rho_1 = 0{\cdot}9554$. The mean distance of *Saturn* is 9·5389 (log. $r_2 = 0{\cdot}9795$) and the log. of its mean distance from the earth is log. $\rho_2 = 0{\cdot}9789$. Thus the brilliancy of *Saturn* was greater on November 20 than at its mean opposition in the ratio of 1·118 to 1, or $H_1 = 1{\cdot}118\ H_2$. Thus *Tethys* = $0{\cdot}000071\ H_2$ or in words, *Tethys in this particular part of its orbit has seventy-one millionths of the brilliancy of the ball of Saturn at mean opposition.*

Zöllner has determined (op. cit. p. 145) the relative brilliancy of *Saturn's* ball at mean opposition of *Capella* to be *Saturn* = 0·431 *Capella;* (log. 9·6345). Hence *Tethys* = 0·000030 *Capella;* (log. 5·4840).

From this we can determine the stellar magnitude of *Tethys.*

If the light of a first magnitude star (as *Capella*) be assumed as 1·000 and if the light-ratio be δ (0·40) and if m be the magnitude of the star on Argelander's scale, then δ^{m-1} = the light of the star in terms of the light of the first magnitude star as unity. For us $\delta^{m-1} = 0{\cdot}000030$ or $m = 12{\cdot}3$ approximately. [On Struve's scale $m' = 11{\cdot}8$. On Herschel's scale $m'' = 12{\cdot}5$.]

The resulting stellar magnitude of *Tethys* on Argelander's scale being as we have seen 12·3 it should be just visible with a telescope of a little over four inches aperture.* This I tested on November 23d, and I find that with four inches aperture *Tethys* was just barely visible at elongation (East) with a power of 200 diameters when *Saturn* was in the field. When *Saturn* was put out of the field it was just steadily visible. With a power of 400 it was better seen, never totally disappearing. With an aperture of five inches on the finder and a power of thirty it was not seen. The appearances were the same to both Anderson and myself. These observations give a rough check on the preceding accurate ones, as the two methods agree better than could be expected. It also affords some evidence as to the eyes of the two observers.

If the relative brilliancy of the various satellites among themselves be measured, the foregoing observations afford a ready means of deducing their brilliancy in terms of a standard star like *Capella* and hence in terms of any standard star.

U. S. Naval Observatory, Washington, 1878, Nov. 25.

* See Pogson: Mon. Not. R. A. S., vol. xxi, p. 34. It is important to remember that in the application of Pogson's formula there is considerable uncertainty owing to the varying effects of different magnifying powers, and to other causes.

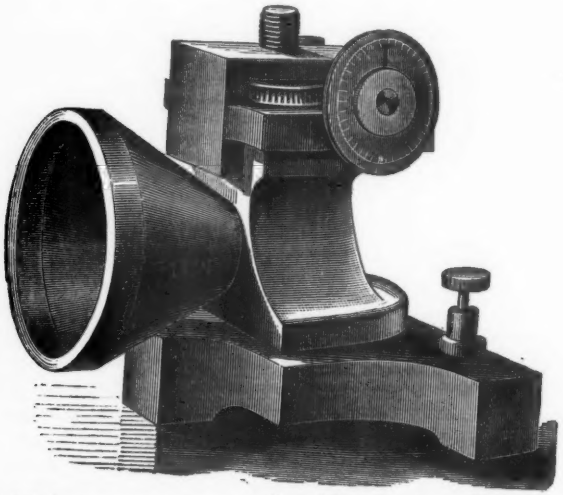
ART. V.—*On the use of the Tasimeter for Measuring the Heat of the Stars and of the Sun's Corona ;** by THOMAS A. EDISON, Ph.D.

To Professor Henry Draper M.D., Director of the Draper Eclipse Expedition :—

Dear Sir : The instrument which I used at Rawlins, Wyoming, during the solar eclipse of July 29, 1878, for the purpose of measuring the heat of the sun's corona, was devised by me a short time only before that event; and the time was insufficient to allow me to give it as thorough a test as was desirable to ascertain its full capabilities and characteristics.

This instrument I have named the tasimeter, from the Greek words *τασις*, extension, and *μετρον*, measure, because primarily the effect is to measure extension of any kind. The form of instrument which I used is shown in the annexed wood-cut (fig. 1.)

1.

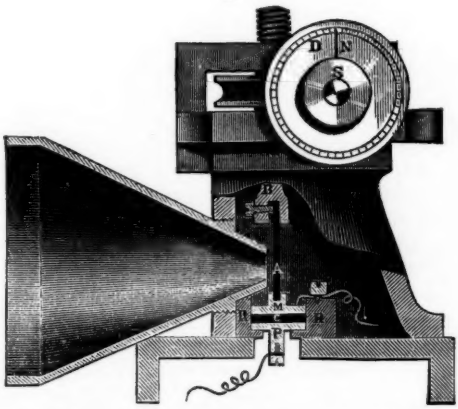


With this instrument was used a Thomson's reflecting galvanometer, on a tripod, and having a resistance of three-fourths of an ohm. The galvanometer was placed in the bridge wire of a Wheatstone balance, two of the branches of which had constant resistances of ten ohms each, while of the other two one had a constant of three ohms, and the other contained the tasimeter which was adjusted by means of the screw to three ohms. When thus balanced if the strip of vulcanized rubber placed between the fixed point and the carbon button (seen in fig. 2)

* Read, by permission of Dr. Draper, at the St. Louis meeting of the American Association.

was exposed to heat from any source, it expanded, producing pressure upon the carbon button, decreasing its resistance and destroying the balance; a current was thus allowed to pass

2.



through the bridge wire containing the galvanometer, the amount of this current of course being proportional to the expansion of the rubber and to the strength of the battery.

The form of instrument here described was only finished two days before leaving for the west; hence I was unable to test it. However, I set it up upon my arrival at Rawlins, but found that it was a very difficult matter to balance so delicate an instrument as a reflecting galvanometer with one cell of a battery, through such small resistances. In fact, I did not succeed in balancing it at all in the usual way. Nor could it be balanced in any way until I devised a method which I may designate "fractional balancing," when it became very easy to accomplish the result and also to increase the effect by using two cells in place of a single one. This device consisted of a rheostat formed of two rows of pins. The rows were about one-half an inch apart. A wire was connected from a pin on one row to a pin on the other row and so on, so that the current had to pass through the whole length of the wire, which was No. 24 gauge and four feet long. This was used as a shunt around the galvanometer. A copper wire connecting all the pins of one row served to reduce the resistance to zero. When the galvanometer was then shunted, a very feeble current passed through it. If the spot of light was not at zero it was brought there by either increasing or decreasing the pressure upon the vulcanite of the tasimeter by the adjusting nut. When thus brought to zero the copper wire of the shunt rheostat was taken off of one

pin, thus increasing the resistance of the shunt perhaps to one-fiftieth of an ohm. The spot of light was generally deflected nearly off of the scale. The light was again brought to zero by varying the resistance of the tasimeter, and another one-half inch of wire included in the shunt, another deflection and another balance was obtained by the tasimeter. Thus by gradually increasing the delicacy of the galvanometer by increasing the resistance of the shunt and balancing at every increase, the whole of the current was allowed to pass through the galvanometer and the shunt taken off. When this point was reached the damping magnet or director was in close proximity to the case of the galvanometer. To increase its delicacy to the fullest extent it became necessary to raise the director to the top of the rod. This was done by raising it cautiously a quarter of an inch at a time, bringing the spot of light to zero each time by the tasimeter.

In order to form some idea of the delicacy of the apparatus when thus adjusted, a preliminary experiment was made on the evening of the 27th, with the star Arcturus. The tasimeter being attached to the telescope, the image of the star was brought on the vulcanized rubber. The spot of light from the galvanometer moved to the side of heat. After some minor adjustments, five uniform and successive deflections were obtained with the instrument, as the light of the star was allowed to fall on the vulcanite to produce the deflection, or was screened off to allow of a return to zero.

It was in this condition when the eclipse occurred. The tasimeter was placed in a double tin case, with water at the temperature of the air between each case. This case was secured to a Dollond telescope of four inches aperture. No eye-piece was used. At the moment of totality the spot of light was slowly passing towards cold. When I withdrew a tin screen and allowed the edge of the luminous corona to fall upon the rubber, the spot of light stopped, went gradually off of the scale towards heat, its velocity accelerating as it approached the end.

The time required for the light to leave the scale was from four to five seconds.

I interposed the screen and endeavored to bring the light back to zero, but I was unsuccessful. Had I known that the heat was so great I should have used a platinum strip in place of the vulcanite, and decreased the delicacy of the galvanometer by the approach of the damping magnet. I then should doubtless have succeeded in getting two or more readings, and afterwards by comparison with bodies of known temperature should have obtained a near approach to the temperature of the sun's corona.

Respectfully yours, THOMAS A. EDISON.

Menlo Park, N. J., August 15, 1878.

ART. VI.—*Description of a Paper Dome for an Astronomical Observatory;* by Professor DASCOM GREENE, Troy, N. Y.

AN astronomical observatory has recently been erected for the Rensselaer Polytechnic Institute, through the liberality of Mr. E. Proudfit of this city. In maturing the plans, and supervising the erection of the building, I have introduced an improved method of constructing revolving domes, a brief account of which may not be without interest.

While making the preliminary inquiries, I ascertained that a dome of the dimensions required, constructed in any of the methods in common use, would weigh from five to ten tons, and require the aid of cumbersome machinery to revolve it. It therefore occurred to me to obviate this objection by making the frame-work of wood, of the greatest lightness consistent with the requisite strength, and covering it with paper of a quality similar to that used in the manufacture of paper boats; the principal advantages in the use of these materials being that they admit of great perfection of form and finish, and give extreme lightness, strength, and stiffness in the structure,—prime qualities in a movable dome. A contract was accordingly made with Messrs. E. Waters & Sons, of this city, the well-known builders of paper boats, for the construction of the dome, and they have carried out the undertaking with great skill and success.

The dome is a hemisphere with an outside diameter of twenty-nine feet. The frame-work consists primarily of a circular sill which forms the base, and two semi-circular arch girders set parallel to each other, four feet apart in the clear, and spanning the entire dome. These are firmly attached to the sill and kept in a vertical position by means of knee-braces. The sill and girders are of seasoned pine, the former being $8\frac{1}{4}$ inches wide by $3\frac{1}{2}$ thick, and the latter each $4\frac{1}{2}$ by 3 inches.

The paper covering of the dome is made in sixteen equal sections, such that when set up side by side, their bases on the sill, and their extremities meeting at the top, they form a complete hemispherical surface. The frame-work of each section consists of three vertical ribs of pine each $3\frac{3}{4}$ inches in width and $\frac{3}{4}$ of an inch thick, one at each side and one midway between, and meeting at the apex. The paper was stretched over this frame-work as follows:

A wooden model of full size being made of that portion of the dome included within one of the sections, with a surface truly spherical, the frame-work of a section was placed

in its proper position on the model, so that its outer edges formed part of the same spherical surface, and covered with shellac where it was to be in contact with the paper. The sheet of paper cut in the proper form was then laid on the model while moist, the edges turned down over the side ribs, and the whole placed in a hot chamber and left until thoroughly dry. In this way the several sections were dried off in succession over the same model. The paper used is of a very superior quality, manufactured expressly for the purpose by Messrs. Crane Brothers, of Westfield, Mass. Its thickness after drying is about one-sixth of an inch, and it has a structure as compact as that of the hardest wood, which it greatly excels in strength, toughness and freedom from any liability to fracture.

After being thoroughly painted, the several sections were ready to be set up side by side on the sill and connected together by bolting through the adjacent ribs. The space between the arch girders being left uncovered on one side from the sill to a distance of two feet beyond the zenith, the upper ends of the sections required to be cut off and accurately fitted to the girders. The joints between sections were made weather proof by inserting a double thickness of heavy cotton cloth saturated with white lead paint. The adjacent side ribs were then bolted firmly together through the paper and cloth, the lower ends attached to the sill by angle irons, the upper ends bolted to the girders, and the lower edge of the paper turned under the sill and securely nailed. The joints were afterwards painted over on the outside. As the entire surface exposed is free from nail holes or other abrasions in the paper, the structure promises with an occasional coat of paint to last for many years, and to form an effective and serviceable roof.

The 4-feet opening between the arch girders is covered by a shutter which is also of paper stretched over a wooden frame. With the exception of about two feet at the lower extremity, this shutter is in a single piece. Attached to its sides are a series of iron rollers which run on a railway track of band iron laid down on the girders, by which means the shutter can be moved over to the opposite side of the dome. The wooden sides of the shutter have iron flanges attached to their lower edges, which project under the railway tracks, making the whole weather proof. The shutter is opened and closed by means of a windlass and wire rope.

The weight of the dome and its appurtenances is about 4,000 pounds. It is supported on six 8-inch balls which roll between grooved iron tracks, and can be easily revolved by a moderate pressure applied directly, without the aid of machinery.

ART. VII.—*On the Age of the Clay-slates and Grits of Poughkeepsie;** by T. NELSON DALE, Jr.

IN Mather's geological sections of the Hudson River valley† the alternating argillaceous schists, slates and grits, on both sides of the river, in the vicinity of Poughkeepsie are assigned to the Hudson River Group. This term was originally intended to include the series between the Utica Slate below and the Medina Sandstone above. These rocks would thus represent the uppermost North American Lower Silurian.

In the geological map drawn by Logan and Hall, and appended to the Report of the Canadian Geological Survey, the rocks for some miles on both sides of the Hudson River, south of Rondout on the west side and of Rhinebeck on the east side, and extending southward beyond Poughkeepsie, are designated as Calciferous and Quebec. They are thus referred to the middle division of the North American Lower Silurian.

Dana, referring to this subject, observes in his Manual of Geology, ed. 1874, on page 184: "The extension of the Quebec group southward, along the west side of the Green Mountain range, covers, according to Logan, a considerable part of New York east of the Hudson, the rock being part of the non-fossiliferous clay-slate (formerly called Hudson River slate) which outcrops near Poughkeepsie, etc. The area is divided on the west from that of the true fossiliferous Hudson River beds (or Cincinnati series, as now called), by a great fault, which, beginning near Quebec, crosses the Hudson near Rhinebeck, fifteen miles north of Poughkeepsie. As these rocks have afforded no fossils, the age is still doubtful." Again on page 196 of the same work, he says, under the head of Cincinnati Epoch: "In New York, the Hudson River beds include shales and sandstones. They are the Lorraine shales of Jefferson County (the Pulaski shales of the New York Annual Reports), containing some thin beds of limestone. The slates along the Hudson River, to which the name was especially applied, have been proved to be in part Primordial, and part, probably of the Quebec series."

These rocks have therefore been first assigned to the Trenton Period, then to the Canadian Period and afterwards declared

* A paper containing the substance of this article, in a different form, and entitled "A contribution to the Paleontology of the vicinity of Poughkeepsie," was read by the author before the Poughkeepsie Society of Natural Science on December 4th, 1878, and is being published in the Proceedings of that Society.

† Nat. Hist. of N. Y., Part IV, Geology, by William W. Mather; Plates 16, 18, 34, 46.

unfossiliferous, and thus a question has been raised as to their real age.

In the spring of 1878, I discovered in a ledge of argillaceous schist, back of the observatory of Vassar College, and a few rods beyond the college fence, some fossil Brachiopoda. Shortly afterward I found others, together with Crinoid stems, at the first ledge of glaciated rock on the Stormville road, between Casper Creek and the first limestone ridge. Again in November and December of the same year, in ascending the first range of high hills which rises about a mile west of the Hudson* opposite Poughkeepsie, I came across a large outcrop of argillaceous schist, containing an abundance of Brachiopoda and Crinoid stems. After it had become known that fossils were to be found in the vicinity of Vassar College, several of the students found some, and Mr. H. Booth of Poughkeepsie, collected a number of Brachiopoda and Crinoid stems at the ledge back of the observatory. On another visit to the locality on the base of Marlborough Mountain, I found a univalve shell and Fucoids.

I am indebted to Mr. James Hall, the State Paleontologist, for the identification of the fossils from these localities. They are: *Orthis testudinaria* Dalm.; *Orthis pectinella* Con.; *Leptæna sericea* Sow.; *Strophomena alternata* Con.; *Buthotrephis subnodosa* Hall.

The cast of the univalve hardly admits of perfect determination, but it strongly resembles that of *Bellerophon bilobatus*. The Crinoid stems measure from one to three millimeters in diameter. There are from thirty-five to forty grooves on the ends, radiating from the central tube to the circumference. The surface is round and smooth. Casts of the central tube, and of the spaces between the joints are preserved, and might easily be mistaken for stems with annular corrugations on the exterior.

In some parts of the rock, Crinoids are very abundant, in others *Orthis testudinaria* forms a conglomerate. *Leptæna sericea*, *Orthis testudinaria* and the Crinoid stems are characteristic of both the Vassar College locality and of that on the west of the Hudson. The Brachiopoda are represented by internal casts, impressions of both exterior and interior, and by the shell itself in a greatly altered state. Sometimes the calcareous shell is preserved with but little alteration. The more minute striæ of *Leptæna sericea* can be counted in some specimens. Nearly all the fossils are more or less distorted. The general character of the rock is the same on both sides of the river. There are irregular alternations of grit, clay slate and shale, in some places,

* I take this hill to be a continuation of what Mather calls Marlborough Mountains.

with thin strata of limestone. The grit is sometimes slightly calcareous.

The geological significance of these fossils is evident. I quote, however, from Hall:* "*Orthis testudinaria:* This species rarely, or never, appears in the Utica slate, but reappears near the middle of the Hudson River shales, and continues nearly to their termination, being abundant at Turin, Lorraine, Pulaski, and other places. It is more rarely found in the vicinity of the Hudson River and in the Mohawk valley." p. 288. "*Orthis pectinella:* This species, though not usually abundant, occurs nevertheless in nearly every part of the Trenton limestone, though unknown to me in the Hudson River group." p. 123. "*Leptæna sericea:* The thin layers in the lower part of the Trenton limestone are often entirely covered with the perfect shells or separated valves of this species. It occurs in all localities of the Trenton limestone. It also reappears in the Hudson River group, being in some localities very abundant." p. 110. "*Strophomena alternata:* This is one of the species, which, commencing its existence prior to or at the epoch of Trenton limestone, continues in great numbers throughout the rock, and, though not appearing in the Utica slate, reappears in the Hudson River group in immense numbers, several thin strata in the upper part of this group being composed almost entirely of the shells of this species." p. 105. The occurrence of these fossils in these localities would then establish the fact that the clay-slates and shales in the vicinity of Poughkeepsie, on both sides of the river, are fossiliferous and that they very probably belong to the Hudson River group, as indicated by Mather in 1843, certainly to some member of the Trenton Period. These facts also speak in favor of the retention of the term Hudson River group as advocated by Hall.†

Poughkeepsie, N. Y., Dec. 12, 1878.

Supplementary Note.—A visit to Marlborough on the west bank of the Hudson River, about eight miles south of Poughkeepsie, has just yielded the following results. In an outcrop of argillaceous schist near the river: *Orthis testudinaria*, *Orthis pectinella*, *Leptæna sericea* and Crinoid stems. In a slightly calcareous grit at the southern extremity of Marlborough Mountain, there called Break-neck Hill, about three miles west of the river at this point: *Orthis testudinaria.*

Poughkeepsie, N. Y., Dec. 16, 1878.

* Nat. Hist. of N. Y. Paleontology, vol. i.

† See Note upon the History and Value of the term Hudson River group in American Geological Nomenclature, by JAMES HALL, of Albany, N. Y., in Proceedings of the Amer. Assoc. Adv. Sci., 1877. This Journal, vol. xvi, p. 482.

ART. VIII.—*On the Electrolytic Estimation of Cadmium;* by EDGAR F. SMITH, Ph.D.

IN a recent article published in this Journal (vol. xvi, Sept., 1878), Professor F. W. Clarke calls attention to the estimation of cadmium by electrolysis, which, however, proved unsuccessful—the cadmium being indeed thrown out of the solution, but in such a form as to enclose impurities; yielding consequently unsatisfactory results.

Out of curiosity to see what might be effected by substituting some other salt for the chloride, I employed an acetate solution and met with success, as the following experiments show:

I. ·1450 grams cadmium oxide were dissolved in acetic acid, the excess of the latter evaporated upon a water bath and then the platinum crucible about half filled with water and placed upon a copper ring connected with the negative pole of a two-cell Bunsen battery, while joined to the wire leading from the positive pole was a strip of platinum foil extending into the acetate solution. The deposition of the cadmium upon the platinum crucible was regular and in a perfectly crystalline grayish white layer. In about three hours the separation was complete. The cadmium was first washed with distilled water, then with alcohol, and finally with ether. It was dried over sulphuric acid. The metallic cadmium weighed ·1270 grams, corresponding to 87·58 per cent Cd. The calculated percentage of metal in the oxide is 87·50.

II. ·2046 grams cadmium oxide placed in a small, rather broad platinum crucible, were dissolved in acetic acid, and after expelling the excess of the latter, water was added—the solution, however, remaining rather concentrated. The platinum vessel was connected with the negative pole of a bichromate battery. To the copper wire of the positive pole was attached a platinum wire from which was suspended a small platinum crucible, which dipped into the solution in the larger vessel. The space between the walls of the two crucibles was not more than an eighth of an inch; only two cells of the battery were employed. The deposit of the cadmium here as in the first experiment was perfectly crystalline and metallic in appearance. Not the slightest trace of spongy metal was visible. The separation was finished in about the same time as in (I). The metal was washed and dried as above. Found ·1790 grams metal, corresponding to 87·48 per cent Cd.

From various experiments made by me I find that good results may be obtained constantly by observing the following: 1st. Work with rather concentrated solutions of the acetate. 2d. Employ a sufficient number of cells of either battery, to give a rapid and rather energetic current.

Laboratory of the University of Pennsylvania, October 31, 1878.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the New Element, Philippium.*—Delafontaine has announced the discovery of a new element, in the earths obtained from the mineral samarskite, to which he has given the name *philippium*, after Philippe Plantamour of Geneva. The oxide of the new metal, philippia, having the symbol PpO, is yellow and has a color and a molecular weight intermediate between yttria and terbia. Admitting it to be a protoxide, the atomic weight of the metal would be between 90 and 95. Philippium formate crystallizes easily in small brilliant rhomboidal prisms less soluble than yttrium formate. The oxalate is more soluble in nitric acid than the terbium salt, less so than that of yttrium. The nitrate becomes dark yellow on heating it to fusion, the terbium and yttrium salts remain colorless. Concentrated solutions of philippium show a spectrum containing a magnificent absorption band in the blue-indigo (λ=4500 about) intense, broad, and well defined, which is characteristic of it, not being found in the spectra of terbium, yttrium or erbium. Two other narrower bands appear in the green, the more refrangible of which appears to belong to erbium, the less to philippium. Observing the spectrum of terbium solutions with sunlight and through blue glass, a weak band was observed in the violet (λ=4000 to 4050 about) only half as broad as the philippium band. The author questions whether it really belongs to terbium as Soret supposes, or to a new element, between terbium and erbium.—*C. R.*, lxxxvii, 559, Oct., 1878. G. F. B.

2. *On the New Element, Decipium.*—Delafontaine has reported the discovery of a second new element in the mineral samarskite from North Carolina, to which he gives the name *decipium*, from decipiens, deceiving. The oxide, if the formula DpO be assigned to it, has a molecular weight of 122; it has not been obtained sufficiently free from didymium oxide to enable the author to say that it is white, though its salts are colorless, the acetate crystallizes easily, being less soluble than that of didymium but more so than that of terbium. Potassio-decipium sulphate is but slightly soluble in a saturated solution of potassium sulphate, though it dissolves easily in water. The nitrate gives an absorption spectrum consisting of at least three bands, in the blue and the indigo. The most refrangible of these is a little less broad than that of philippium, is dark, and corresponds in its center to a wave length near 4160, being about half way between G and H. Neither didymium nor terbium gives bands in this region. The second band is narrow, intense, not defined on its edges, and is in the less refrangible part of the blue, corresponding to a wave length of 4780; nearly in the same place as one of the didymium bands, but far more intense. Finally a little to the right and

nearly to the limit of the blue and green is an appearance of the third. The earths of samarskite as now known are given by the author in the following tabular form:

Name.	Color.	Molec. weight.		Wave length of Charac. band.
Yttria	White	YO =74·5	(Delafontaine)	None.
Erbia	Rose	ErO =130	(Bunsen-Clève)	520–522
Terbia	Orange	TbO =114–115	(Delafontaine-Marignac)	400 about.
Philippia	Yellow	PpO =90 about	(Delafontaine)	449 about.
Decipia	White ?	DpO =122 about	(Delafontaine)	416
Thoria	White	ThO_2=267·5	(Delafontaine)	None.
Didymia	Brownish	DiO =112–114	(Marignac-Clève)	572–577
Ceria	Pale yellow			

He also calls attention to the numerical relations between the atomic weights, thus: Yttrium = 58; Philippium = 74 or 58+2×8; Terbium 98 or 58+5×8; Decipium 106 ? or 58+6×8; and Erbium=114 or 58+7×8.—*C. R.*, lxxxvii, 633, Oct., 1878.

G. F. B

3. *On the New Element, Mosandrum.**—At a recent meeting of the French Academy (November 25th, 1878), a note by Dr. J. Lawrence Smith was presented, in which he claimed for himself priority in having been the first to call attention to the absence of cerium oxide, and to the new characters of certain earths, in the North Carolina samarskite, and to have described one of these under the name Mosandrum.

4. *On the New Element, Ytterbium.*—MARIGNAC has described some of the compounds of a new element, found in the Ytterby mineral gadolinite; it is associated with yttrium and erbium, and hence called by him *ytterbium*. In separating the earths of this mineral, he heated the mixed nitrates until they became pasty. On treating the mass with boiling water, an insoluble residue remained, in which the erbium was concentrated. By repeating the operation many times, a pure rose colored earth was obtained, which was erbia, the atomic weight rising to that of erbium, 128 or 129. On continuing the operation, he was surprised to find that the increase of the rose color, of the absorption bands and of the atomic weight which at first kept together, finally separated; the atomic weight slowly increasing, while the rose color and the bands diminished; so that the last product was perfectly white, its salts were colorless and its spectrum showed no absorption bands. The purest product gave an atomic weight of 130·8; hence 131 may be provisionally adopted. Ytterbium nitrate is decomposed by heat without coloration, the oxide is much less attackable by acids than the other oxides of this group, the sulphate is isomorphous with those of yttrium and erbium, redissolves easily and completely in a saturated solution of potassium sulphate, no precipitate being formed on boiling, the chloride in neutral solution is not precipitated by boiling with sodium hyposulphite, the formate dissolves in less than its weight of water and resembles the same salt of yttrium and erbium, and loses its crystal water at 100°. These properties distinguish it from thorium, the only element of this kind known

* This Journal, xvi, 334, November, 1878.

whose atomic weight is high. Its symbol is Yb.—*C. R.*, lxxxvii, 578, Oct., 1878. G. F. B.

5. *On a Simple Vapor density Method.*—Victor Meyer has proposed a very simple mode of approximate vapor density determination, dependent on the measurement of the air expelled by the vapor. He uses an elongated cylinder of about 100 c. c. capacity, closed at bottom and having a tube of some length attached at top, in the side of which is a lateral tube by which the air may be conducted to a graduated tube. The vertical tube is to be closed with a cork. To use it, the apparatus is placed in the vapor of a liquid of sufficiently high boiling point, or even in a metallic bath. After the temperature has become constant and the air in the cylinder has finished expanding, the end of the lateral delivery tube is placed beneath a graduated tube full of water, the cork is removed, the substance dropped through the tube into the cylinder, and the vessel closed. The substance volatilizes at once and expels its own volume of air from the vessel, which is collected and measured in the graduated tube. Neither the capacity of the vessel nor the temperature of the bath are needed in the calculation. This requires only the weight of the substance, the temperature of the room, the height of the barometer and the volume of air expelled. The results are close enough for molecular weight determinations, as the figures given show.—*Ber. Berl. Chem. Ges.*, xi, 1867, Nov., 1878. G. F. B.

6. *On the Separation of Zinc from Nickel.*—Beilstein has proposed the use of citric acid in the analytical separation of nickel from zinc, having found that in presence of citric acid and citrates, zinc is completely precipitated by hydrogen sulphide, while all the nickel remains in the solution. The solution containing the two metals, which must be quite dilute and contain them as nitrates or sulphates, is treated with ammonia to alkaline reaction and is then acidulated with pure citric acid. Into the perfectly cold solution, hydrogen sulphide is passed for five or ten minutes, or until it strongly smells of the gas, allowed to stand for an half hour, repeating the operation until the odor no longer disappears on standing. The precipitated zinc sulphide is allowed to stand twenty-four hours in the cold, is filtered off and weighed. The filtrate is evaporated to a small bulk and from it the nickel is precipitated electrolytically. The separation is complete as is shown by the examples given.—*Ber. Berl. Chem. Ges.*, xi, 1715, Oct., 1878. G. F. B.

7. *On the formation of Purpureo-chromium salts.*—Jörgensen has succeeded, by the oxidation of an ammoniacal solution of chromous chloride $CrCl_2$, in producing a chloride of chloro-purpureochromium, the original sky-blue fluid becoming of a beautiful red color. The formula of the chloride of the new compound is $Cl_2[Cr_2(NH_3)_{10}]Cl_4$, analogous to purpureocobalt chloride, which it resembles in solubility. From aqueous solutions it is completely precipitated by hydrochloric acid. Nitric acid produces

in the aqueous solution a magnificent carmine red chloro-nitrate of the composition $Cl_2[Cr_2(NH_3)_{10}]$ $(NO_3)_4$. In the solutions of this salt the chlorine is not precipitable by silver nitrate. Fluosilicic acid precipitates a silico-fluoride of chloropurpureochromium, which under the microscope appears isomorphous with the corresponding cobalt salt. The author has evidence of the existence of roseo and luteo-chromium.—*J. pr. Ch.*, II, xviii, 248, Nov., 1878.

G. F. B.

8. *On the Atomic weight of Iridium.*—SEUBERT has re-determined with great care the atomic weight of iridium, by igniting in a current of hydrogen, ammonio-iridium chloride and potassio-iridium chloride. The former gave as a mean 193·377; the latter 193·094; the mean of both being 193·220, H being 0·9975; or taking H as 1, the atomic weight of iridium is 192·744.—*Ber. Berl. Chem. Ges.*, xi, 1767, Oct., 1878.

G. F. B.

9. *Preliminary Note upon the nature of the Chemical Elements.*—Mr. NORMAN LOCKYER has addressed the following note to the French Academy of Sciences:—"Reasoning from analogies furnished by the behavior of known compounds, I have proved that, independently of calcium, many bodies hitherto considered as elements, are also compound." Mr. Lockyer promises to forward to the Academy the necessary proofs of his assertion."—*Comp. Rend.*, No. 19, p. 673, Nov., 1878.

J. T.

10. *Phenomena of Binaural Audition.*—Professor THOMSON, of University College, Bristol, England, thus sums up the results of his investigation upon this subject. "(*a.*) There is an interference in the perception of sound; for two simple tones capable of interfering are still heard to interfere when conducted separately to the two ears. (*b.*) When two simple tones in unison reach the ears in opposite phases, the sensation of the sound is localized at the back of the head. (*c.*) The localization of this acoustic "image" is independent of the pitch of the sound. (*d.*) If the difference of phase is partial, the sensation is localized partly in the ears and partly at the back of the head. (*e.*) If the difference of phase be complete but the intensities unequal, the acoustic "image" instead of being at the middle of the back of the head, is nearer that ear in which the sound is louder. (*f.*) It is possible to discern the difference between two compound tones which differ only in the phase but not in the pitch or intensity of their component partial tones. For when two such compound tones are separately brought to the ears so that the vibrations of any partial tone present reach the ears in opposite phases, that particular partial tone is singled out and localized at the back of the head. (*g.*) When two simple tones are led simply to the ears no differential tone is heard; there is some evidence that summational tones are heard. (*h.*) To binaural audition dissonances are excessively disagreeable and ordinary consonances harsh. (*i.*) Vibrations mechanically conveyed to a point of the parietal or occipital region of the skull at one side, are apparently heard in the ear of the other side of the head."

In his investigation the author made use of a telephone, which is thus seen to occupy a place in acoustic researches.—*Phil. Mag.*, Nov., 1878, p. 383. J. T.

11. *On the Economy and Subdivision of the Electric Light.*—Professor FARMER of the Torpedo Station at Newport, has written a letter to the Salem Observer, calling attention to the fact that the parlor of his house, No. 11 Pearl St., was lighted every evening during the month of July, 1859, by the electric light, and that this electric light was subdivided, too. Since this was nineteen years ago, it was, he thinks, undoubtedly the first private dwelling house ever lighted by electricity; a fact which may be a source of pride to the city of Salem some of these days. As we know of no one better qualified to give an opinion on these important questions, we give the latter portion of Professor Farmer's letter:

"A galvanic battery of some three dozen six-gallon jars was placed in the cellar of the house, and it furnished the electric current which was conveyed by suitable conducting wires to the mantle-piece of the parlor, where were located two electric lamps, on each end of the mantle-piece—(I should not wonder if the screw holes were there at this day). Either lamp could be lighted at pleasure, or both at once, by simply turning a little button to the right for a light, to the left for a dark. No matches, no danger, no care to the household, nor to anyone except to the man who attended to the battery.

This light was noticed as being soft, mild, agreeable to the eye, and more delightful to read or sew by than any light ever seen before. Its use was discontinued, at that time, for the simple reason that the acids and zinc consumed in the battery made the light cost about four times as much as an equivalent amount of gas-light. Now that we can have cheap electricity from the dynamo-electric machine, we may soon expect better things of it.

In the year 1875 I subdivided an electric current into forty-two different branches, putting a light into each branch. All these lamps were supplied with electricity from one machine, which did not weigh more than eight hundred pounds, and which was driven by a small steam engine.

Now a word as to the cost of electric light as compared with light from gas. Perhaps on the average, one pound of illuminating gas will, if burned in an hour in five different burners, give fifteen candle lights to each burner, or seventy-five candle lights in all. One pound of illuminating gas possesses a sufficient store of energy to enable it to give out by combustion, from eighteen thousand to twenty-one thousand units of heat, or the equivalent of from thirteen to sixteen million foot-pounds of work. This, if burned in an hour, would average from two hundred to two hundred and sixty thousand units of work per minute, or say from three thousand to thirty-five hundred foot-pounds per minute per candle light.

Now a very large electric light, say ten thousand candles,

does not demand or consume more than fifteen or twenty foot-pounds of energy per minute per candle light, and even so small an electric light as twenty or thirty candles need not consume so much as two hundred foot pounds per minute per candle light. So it might not seem very extravagant to expect that one pound of gas per hour could be burned in a suitable furnace under a proper boiler, and steam be taken from this boiler to a steam engine, and this engine drive a magnetic electric machine which should supply electricity to five electric lamps that would shed forth more light than could be given by five of the best gas lamps known, each lamp consuming at the rate of one-fifth of a pound of the best illuminating gas per hour; and this would not be half so absurd an expectation as it would have been three years ago, for some visionary to have predicted that the talking Phonograph would succeed in embalming speech."

U. S. Naval Torpedo Station, Newport, R. I., Oct. 30, 1878.

II. Geology and Mineralogy.

1. *Report of the Geological Survey of the Fortieth Parallel*, Clarence King, Geologist in charge: Volume I, *Systematic Geology*, by Clarence King. 804 pp. 4to, with 28 plates and 12 analytical geological maps, and accompanied by a geological and topographical atlas. Submitted to the Chief of Engineers, and published by order of the Secretary of War, under authority of Congress.—The field work of the Geological Survey of the 40th Parallel commenced in 1867, and continued until 1873; the no less important labor of studying the material collected, arranging for publication facts observed, and drawing conclusions from them has only been finally concluded during the past year. The study of the geology of the region explored was carried on by Mr. King and his associates, Mr. Arnold Hague and Mr. S. F. Emmons, of the mining districts by Mr. J. D. Hague, and of the botany by Mr. S. Watson; the topography was in the hands of Mr. J. T. Gardner.

The area covered by their explorations forms a belt of country 100 miles wide, from north to south, and extending from the meridian 104° west in a direction a little south of west as far as longitude 120° west; it partly encloses the 40th Parallel, but near the eastern extremity deviates a little to the north of the line. Of this tract of country Mr. King says, in the opening chapter of his volume: "It has rarely fallen to the lot of one set of observers to become intimate with so wide a range of horizons and products. Embracing within its area a pretty full exposure of the earth's crust from nearly the greatest known depths up through a section of 125,000 feet, taking in all the broader divisions of geological time—a section which has been subjected to a great sequence of mechanical violence, and can hardly fail to become classic for its display of the products of eruption—this Exploration has actually covered an epitome of geological history." It should be added that, at the time when Mr. King's party took the field, the

region was one which was unmapped, unstudied, and of which nothing but a few isolated details was known. The value of the work accomplished can be best appreciated when the difficulties which had to be overcome are understood.

The several volumes of the Survey, in their order of publication, are as follows:—Vol. iii, Mining Industry, by James D. Hague, with geological contributions by Clarence King, 1870. Vol. v, Botany, by Sereno Watson. Vol. vi, Microscopical Petrography, by Ferdinand Zirkel, 1876. Vol. ii, Descriptive Geology, by Arnold Hague and S. F. Emmons, 1877. Vol. iv, Part I, Palæontology, by F. B. Meek; Part II, Palæontology, by James Hall and R. P. Whitfield; Part III, Ornithology, by Robert Ridgway, 1877. Geological Atlas, containing ten double maps, 1878. Vol. i, Systematic Geology, by Clarence King, 1878.

The concluding volume in the series, now published, presents a systematic statement of the geological facts taken in order of geological time, collected by Mr. King and his associates, Messrs. Hague and Emmons, with the conclusions which he himself has drawn from them. The detailed presentation of these facts, in their geographical order, had already been given in volume ii, on Descriptive Geology (noticed in this Journal, vol. xvi, p. 234). In thus bringing together in a single volume the grand results of his Survey, Mr. King has given much greater and more permanent value to the labors of himself and his associates. The clear and systematic manner in which both the facts observed and the theories advanced are presented, is worthy of high praise; Mr. King's graceful pen never showed itself to better advantage. It is perhaps unnecessary to add that the appearance of the volume is all that could be desired; the many plates are executed in the best manner. An especially valuable feature of the volume is to be found in the series of geological charts, one of which accompanies the description of each formation and gives the distribution of the rocks belonging to it. In another number we expect to cite some pages from the work, which will show some of the more important conclusions reached.

2. *Tenth Annual Report of the United States Geological and Geographical Survey of the Territories.* Being a Report of Progress of the Exploration for the year 1876, by F. V. Hayden, U. S. Geologist; 546 pp. 8vo, with 74 plates and 3 large maps. Washington, 1878.—This large and valuable volume contains, besides the opening letter of the geologist in charge, the following reports: Part I, by C. A. White, On the geology of a portion of Northwestern Colorado; by F. M. Endlich, on the geology of the White River District, on the Mineralogy of Colorado, and on the Erupted rocks of Colorado; by A. C. Peale, on the geology of the Grand River District; by W. H Holmes, on the geology of the Sierra Abajo and West San Miguel Mountains; Part II, Topographical reports by A. D. Wilson, Henry Gannett, G. B. Chittenden and G. R. Bechler; Part III, On Archæology and Ethnology by W. M. Holmes, W. H. Jackson and W. J. Hoffman; and

Part IV, On Cretaceous and Tertiary plants by Leo Lesquereux; On injurious Insects by A. S. Packard, Jr. The Archæological reports contain detailed descriptions of the ancient ruins in Southwestern Colorado and adjacent territories. A large number of excellent plates, illustrating both the distribution and character of the cliff houses, and also the remains of pottery and other implements found in connection with them, besides admirable plans, sketches, sections, increase the value of the reports. The Report contains also two beautiful colored geological maps of Colorado, and a third map giving the drainage of the Territory.

3. *Bulletin of the United States Geological Survey of the Territories;* F. V. HAYDEN, Geologist-in-charge. Vol. iv, No. 4.—This number of the Bulletin contains papers by S. H. Scudder on the fossil Insects of the Green River shales; by D. S. Jordan on Fishes of Dakota and Montana, collected by Dr. Coues; by J. W. Chickering on Plants of Dakota and Montana, collected by Dr. Coues; by F. M. Endlich on Erosion in Colorado; by C. A. White on the Laramie Group; by J. A. Allen on the American Sciuri or arboreal squirrels. An index to volume iv closes the number.

4. *On the Origin of Stylolites;* by EDWARD T. NELSON. (Communicated.)—During the past summer while spending a few days at a Post of the Hudson's Bay Company, called Red Rock, situated three miles above the mouth of Nipegon River, Lake Superior, I had opportunity for observing the formation of stylolites on a grand scale. The left bank of the river, just below Nipegon Rapids, is, perhaps, fifty feet in height, and is composed of strata of fine sand, with thin intercalated layers of clay. Owing to the protecting influence of the clay the face of the bank presents a series of steps. For a distance of some hundreds of feet, and vertically from top to bottom, the surface, at the time of our visit, was covered with stylolitic columns. In each case these columns reached from one stratum of clay to the next below, and hence varied in height from two inches to as many feet. During the first afternoon it was raining gently. The water falling over the edges of the exposed layers of clay washed the *sand vertically from beneath.* In this way each stratum of sand presented the same projections and crevices as its covering layer of clay. As soon as the sun came out the exposed edges of the stylolites became covered by a very thin pellicle of the clay and were thus preserved. Wishing to learn whether these columns became sufficiently hard to stand pressure, I removed, very gently, portions of the talus of sand from the base of the hill and found within perfectly preserved columns. The inner face of the talus was, of course, the exact obverse of the stylolites.

Ohio Wesleyan University, Oct. 22d, 1878.

5. *Bowlders in Coal.*—During a recent geological excursion with the Senior class of Denison University, I found at New Straitsville, Perry County, Ohio, a bowlder of hard gritty sandstone, ten inches in diameter, in a seam of coal. It was covered to the depth of one foot and rested upon seven feet of coal, the

seam being the Nelsonville, or "Great Vein," which lies two to three hundred feet above the base of the Coal-measures. The roof is a bluish gray shale containing the usual Carboniferous fossils.

It seems improbable that this bowlder was brought into the ancient marsh when the material for the lower seven feet of coal had accumulated, and was then covered with the several feet of vegetable matter which are now compressed into the upper foot of coal. The Nelsonville seam has a wide distribution in southeastern Ohio and Kentucky. It is the most reliable and persistent coal of the lower productive measures. This implies that the marsh in which it accumulated was very widespread, and that it long retained its character as an area of sluggishly moving, or stagnant waters, so choked with rank vegetation that drift-wood or floating ice (if any such thing existed in that age) would have no chance of being carried far over its surface. But it afterward sank beneath a shallow sea, muddy with the sediment which is now hardened into the roof shales. Sometimes during this submergence the bowlder was dropped upon the still soft and yielding mass of vegetation and sank into it to a considerable depth. By what agency it was transported from the shores of that ancient sea to its present resting place is uncertain. Two similar cases are on record, and two eminent Ohio geologists have speculated upon the causes of the phenomena. Professor E. B. Andrews (Report of Progress, 1870, p. 78) mentions a large quartzite bowlder in this same Nelsonville seam at Zaleski, Vinton County, and attributes its transportation to floating ice. Professor J. S. Newberry (Ohio Reports, vol. ii, p. 174) mentions one of talcose slate found by him in Coal No. 2, in Mahoning County, and opines that it was brought there by being "entangled in the roots of trees, and thus floated and dropped." Whatever may have been the buoyant material we can readily conceive that, once upborne upon the water, these bowlders might easily have been driven by winds, or carried by currents, to where we now find them, and penetrated the material of the coal by virtue of their weight and compactness, while the mud carried by the same waters spread over the coal a sheet of fine sediment without mingling with it.

Granville, Nov. 19th, 1878. L. E. HICKS.

6. *Ashburner on Oil-well Records in McKean and Elk Counties, Pennsylvania.*—In a citation from this memoir on page 393 of the preceding volume, the sentence reading "We are sure that the rocks maintain a constant thickness between these two points," should read "We are not sure," etc.

III. Botany and Zoology.

1. *Flora Brasiliensis.*—The publication has made great progress during the year 1878. In February appeared fascicles 75 and 76; in June fasc. 77, in August fasc. 78. The subjects, in order of publication, are:

Hippocrateaceæ, by Dr. J. Peyritsch, Curator of the Vienna

herbarium. While retaining the order, it is remarked that one isomerous genus makes a transition to *Celastraceæ*.

Meliaceæ, by Casimir DeCandolle, who has recently published a monograph of the whole order in the series which is to continue and supplement the Prodromus. This order is not very largely developed in Brazil.

Hederaceæ, by E. Marchal, Professor of Botany at Brussels. The Brazilian species belong to four genera, which are well illustrated.

Lemnaceæ, by Professor Hegelmaier of Tübingen, the monographer of the order. The three genera, *Wolffia*, *Lemna*, and *Spirodela* are well illustrated in a single plate, and the anatomy and morphology are fully expounded.

Araceæ, by Professor Engler, late of Munich, now translated to Kiel. There are about ninety Brazilian species out of 738 known to the monographer, who arranges them under ten sub-orders, and the larger sub-orders have two, three, and five tribes. But among the sub-orders are *Pistiaceæ* and *Lemnaceæ*. The whole is evidently worked out conscientiously, and is admirably illustrated by fifty-one plates, which abound in analyses. One of them is a photograph of magnified stem-sections.

Rafflesiaceæ, by Count Solms-Laubach, Professor at Strassburg. In Brazil are two known species of *Apodanthes* and four of *Pilostyles*. The single plate of illustrations is excellent.

Nymphæaceæ, by Professor Caspary of Kœnigsberg, are amply and well illustrated. Three folio plates are given to *Nymphæa ampla* and its varieties, six to other species, and two to *Cabomba* and some details of *Victoria*. Three typical species of *Cabomba* are described, and the character of *C. Caroliniana*, with full descriptive details is given in a foot-note. The *Nelumbium* of South America proves to be *N. luteum;* and the Japanese *N. nuciferum* is thought to be hardly different. Three species of *Victoria* are indicated, but with doubts as to their distinctness. One of the ten tropical American species of *Nymphæa*, viz: *N. ampla*, well marked by having the carpels separate through the center and cohering only dorsally, reaches Texas.

Cucurbitaceæ are elaborated, with much detail, by A. Cogniaux, a Belgian botanist. Introductions included, there are twenty-nine Brazilian genera, and one hundred and eleven species, arranged under the series proposed in Bentham and Hooker's Genera Plantarum. Eichler is followed in placing the order next to Campanulaceæ, a reversion to the ideas of Bernhard Jussieu and Adanson. *Cucurbita Pepo* is thought to be of Asiatic origin; perhaps rightly. But our Indians had it, along with *Nicotiana rustica*, which is certainly an old-world species. *Echinocystis* is still mixed up with *Megarrhiza*—a wholly distinct genus,—and with two Brazilian plants which, we venture to say, are not congeners of the true *Echinocystis*. The order is here illustrated by thirty-eight plates. A. G.

2. Heer: *Flora Fossilis Arctica.* Tome v. 1878.—This new volume, like most of its predecessors, is composed of separate

memoirs, some here first printed, some extra issues from academic transactions and the like. The first paper, on the Miocene Flora of Grinnell's Land (with nine plates and a map and sketch), is originally printed at Zurich. The two following papers, on Siberian and Eastern Asian fossil plants, are from the Memoirs of the Imperial Academy of St. Petersburg; the remaining two are from the Memoirs of the Royal Swedish Society at Stockholm, and illustrate the Miocene flora of Sachalin and the *Cordaites* of Nova Zembla. There are numerous figures. The first named paper most interests us, by the announcement of the discovery of the remains of a Miocene Spruce of the *Tsuga* group, i. e., allied to our Hemlock Spruce; also of the veritable Silver Fir of Europe! A. G.

3. *Epping Forest, and how best to deal with it*, is an article in the Fortnightly Review for November last, and separately issued, by Alfred R. Wallace. It urges—now that the ground which this ancient forest in the neighborhood of London covered, and in part still covers, is consecrated by act of Parliament for the recreation and enjoyment of the public forever—that the large waste portions shall be replanted in a way that may exemplify and reproduce, separately, the several kinds of forest of the northern hemisphere. Even some forests of the temperate portions of the southern hemisphere—of New Zealand, for instance, may be hopefully planted. The complete feasibility and the great interest of this project are well set forth, and are fortified by the authority of this Journal. Mr. Wallace, who is exceedingly well qualified to judge, adopts fully the theoretical views which are maintained in recent articles of this Journal, as to the cause of the poverty of Europe in indigenous trees, in comparison with North America and Eastern Asia, and her own Tertiary epoch; and would reclaim for England the trees and shrubs of which she was long ago deprived by icy fate. A. G.

4. *Die Algenflora des Weissen Meeres;* by Dr. Cristoph Gobi. (Extr. from Mem. Imp. Acad. Sciences, St. Petersburg, vol. xxvi, no. 1.).—The above named paper is the first detailed account of the algæ of the White Sea. The species are principally those found throughout the Arctic Ocean; but Dr. Gobi remarks that the vegetation of the southern part of the White Sea has a more northern character than that of the northern part; which is explained by the statement that many forms of Western Europe which make their way to the northern part do not extend to the southern part of the White Sea. Dr. Gobi unites a considerable number of species considered by Agardh and others to be distinct, even regarding *Rhodomela lycopodioides* as a form of *R. subfusca*, and *Polysiphonia arctica* as a variety of *P. variegata*. *Rhodophyllis veprecula* Ag. is referred to *R. dichotoma* Lepechin. The paper contains valuable references to the species of Ruprecht in the St. Petersburg Academy's herbarium. W. G. F.

5. *North American Fungi: Fungi Americani, Centuries I and II;* by H. W. Ravenel and M. C. Cooke. *North Ameri-*

can Fungi; by J. B. Ellis.—Since the *Fungi Caroliniani Exsiccati* by Ravenel, the last volume of which appeared in 1860, a large number of new species of fungi have been described by writers in Europe and this country, only a small number of which have ever been issued in any of the series of Exsiccati, which have in recent years become uncomfortably numerous. Several American species, to be sure, have been published in Thümen's Mycotheca Universalis, but, comparatively speaking, the number is small. From the nature of the plants themselves, and the fact that many mycologists remote from one another are constantly describing new species, many of which are founded on very minute distinctions, it is very much to be desired that an authentic series of American fungi should be in the hands of leading mycologists of Europe and this country. For this reason, if for no other, we welcome the fasciculi just issued by Messrs. Ravenel and Cooke, and that by Ellis.

The first series named includes specimens collected in Georgia and Florida by Mr. H. W. Ravenel, whose *Fungi Caroliniani* have made his name familiar to all students of fungi. The determination of the species and their arrangement has been undertaken by the well-known British mycologist, Mr. M. C. Cooke. The series will include about four hundred species, published in centuries, at the rate of twenty-one shillings each. American orders may be addressed to H. W. Ravenel, Aiken, S. C. The series includes a number of new species, which are being described in the current numbers of Grevillea.

The second of the series named is issued by Mr. J. B. Ellis, of Newfield, N. J.; and the first century contains species collected by him in the vicinity of Newfield, including a number of the new species described by Cooke and Ellis in Grevillea, and by Ellis and Von Thümen in the Torrey Bulletin. Mr. Ellis intends in the succeeding centuries of his work to include species from all parts of the United States, and has secured the aid of several mycologists in different parts of the country, who will furnish specimens and, at times, descriptions of species. So far as is practicable, an effort will be made to place in the same fasciculus only plants belonging to the same order, so that the student will find a large suite of related species placed near together for comparison. Century II will contain principally *Ascomycetes*, by Mr. Ellis, and Century III, *Uredinei*, by W. G. Farlow. The series will include common as well as rare forms, and it is to be hoped that it may become for this country what Rabenhorst's *Fungi Europæi* is for Europe. Each fasciculus is neatly bound in a form similar to that of Rabenhorst's Fungi, and is sold at the rate of $7.00. Orders can be sent to J. B. Ellis, Newfield, N. J.

W. G. F.

6. *The Early Types of Insects;* by Samuel H. Scudder. (Abstract of a paper read before the National Academy of Sciences, November 5, 1878).—The earliest remains of insects from the Paleozoic rocks were announced in 1835 by Audouin and

Corda. Since then many authors, especially Germar and Goldenberg, have added to our knowledge, until now perhaps one hundred species are known. Yet insect remains in the older strata may still be looked upon as the greatest rarities, and by far the larger part of them are known to us only by their wings.

It is of course of prime importance that we should understand the relative subordination of the larger groups in insects before investigating their order of succession in time; for one of the principal difficulties in attempting to harmonize their structural and geological relations has been in the erroneous views which have been maintained of the relative rank of the suborders of Hexapods and of their division into series. The author contended for the accuracy of Packard's classification, which separated them into Metabola and Heterometabola, the former including the Hymenoptera, Lepidoptera and Diptera; the latter the Coleoptera, Hemiptera, Orthoptera and Neuroptera, the arrangement being in a descending order. He was also inclined to agree with Dohrn in his estimate of the ordinal value of the peculiar combination of characteristics in Eugereon and other early insects and to accept, but with somewhat different limits, the term Palæodictyoptera applied to this group by Goldenberg. He discussed the times of appearance and relative abundance of the different suborders of Hexapods and concluded with the following recapitulation:

(1.) With the exception of the few wings of Hexapods known from the Devonian, the three orders of insects—Hexapods, Arachnids and Myriapods—appeared simultaneously in Carboniferous strata. (2.) All Carboniferous and Devonian insects are Heterometabola, the Metabola making their first appearance in Jurassic strata. (3.) Many synthetic or comprehensive types existed in Paleozoic times, combining the characters either of all the Heterometabola; of Orthoptera and Neuroptera; or of Neuroptera proper and Pseudoneuroptera. (4.) The Devonian insects either belong to comprehensive types related to the two lower suborders only, or are low Pseudoneuroptera; and were undoubtedly aquatic in early life. (5.) The lower suborders of Heterometabola (Orthoptera and Neuroptera) were much more abundant in Paleozoic times than the higher (Coleoptera and Hemiptera). (6.) Nearly all the Paleozoic Orthoptera belonged to the lower, nonsaltatorial families, and are almost exclusively cockroaches. (7.) The Neuroptera proper were at that time much rarer than the lower Pseudoneuroptera. (8.) All the earlier types were therefore of inferior organization. (9.) The general type of wing structure in insects has remained unaltered from the earliest time. (10.) With the exception of two species of Coleoptera, the front and hind wings of Paleozoic insects were similar and membranous. (11.) The series of facts presented to us by the progress of geological research leads to the conviction of the probable existence and possible discovery, in the Devonian and even in the Silurian formation, of winged insects, still more generalized in structure than any yet detected in the Paleozoic rocks.

It may further be added that nearly all the earlier insects were large, many of them gigantic in size; and further, that there is a striking similarity between the Carboniferous insect fauna of Europe and North America.

IV. Astronomy.

1. *Constants of the Terrestrial Spheroid.*—In the Astron. Nach., No. 2,228, Professor Listing gives the following results of his determination of the constants of the earth's figure:

a	$= 6{,}377{,}377^{m}$	l_0	$= 990{\cdot}9948^{mm}$
b	$= 6{,}355{,}270^{m}$	l^*	$= 993{\cdot}5721^{mm}$
R	$= 6{,}377{,}000^{m}$	l'	$= 996{\cdot}1495^{mm}$
Q_0	$= 10{,}017{\cdot}560^{m}$	g_0	$= 9{\cdot}780728^{m}$
Q	$= 10{,}000{,}205^{m}$	g^*	$= 9{\cdot}806165^{m}$
w	$= 288{\cdot}4800$	g'	$= 9{\cdot}831603^{m}$

Also in general, $l = 990{\cdot}9948 + 5{\cdot}1547 \sin^2 \varphi$,

$$g = 9{\cdot}780728 + 0{\cdot}050875 \sin^2 \varphi.$$

In these expressions a = equatorial rad., b = polar rad., $R = (a^2 b)^{\frac{1}{3}}$, or mean radius, Q_0 = equatorial quadrant, Q = meridian quadrant; $w = a \div (a - b)$, or eccentricity of merid. section; l_0, l^* and l' are the lengths of the second's pendulum at the equator, 45°, and pole; g_0, g^* and g', the force of gravity at the equator, 45° and pole; and l and g the corresponding values at any latitude φ. H. A. N.

2. *Failure of Meteors from Biela's Comet in* 1878.—Mr. E. T. Sawyer writes from Cambridge as follows, under date of December 9th:—As far as my observations show, the expected shower of Biela's, proved a complete failure. I carefully looked for meteors conformable to a radiant near γ Andromedæ on the following dates: –November 23, 24, 26, 29, 30, and December 6, 7, and 8. The watches each evening varied from one to four hours in duration, and aggregate about seventeen hours in all. Cloudy weather interfered with watching for a week previous to the 23d, with the exception of a few minutes on the 21st, also on the 25th, 27th, 28th, and December 1st, 2d, 3d, 4th, and 5th. Strong moonlight also prevented the recording of faint meteors after November 29th. During the seventeen hours or more of watching, only three meteors were mapped radiating with any certainty from the deduced center near γ, and these paths prolonged backward meet exactly at R. A. 25° and 42°. Of the three recorded, two were seen during the four hours' watch on the 26th. H. A. N.

3. *Abriss der Praktischen Astronomie*, von Dr. A. Sawitsch, translated into German from the 2d Russian edition, by Dr. C. F. W. Peters, assistant in the Observatory at Kiel. 848 pp. 8vo, Wilhelm Mauke, Leipzig, 1879.—The first edition of this work, translated from the Russian by Dr. Götze in 1850, has been for near thirty years a standard work for the subjects embraced in it. It is devoted principally to the instruments and processes

employed in the determination of latitudes and longitudes. It does not describe the fixed instruments of the observatory, and is therefore more complete in respect to portable ones.

The present edition has been quite fully revised, the changes in instruments and improvements of methods having required considerable changes in the matter. The Repsold vertical circle and the Ertel universal instrument are especially described. The more recent methods of utilizing solar eclipses for determination of longitude replace the older ones. H. A. N.

V. Miscellaneous Scientific Intelligence.

1. *International Geological Congress.*—The American Association for the Advancement of Science, at its meeting in Buffalo, August, 1876, appointed an international Committee charged with the organization of an International Geological Congress, to be held in Paris during the Exhibition of 1878. This committee, which consisted of James Hall, W. B. Rogers, J. S. Newberry, J. W. Dawson, T. Sterry Hunt, R. Pumpelly and C. H. Hitchcock, with the addition of T. H. Huxley, Otto Torell, and E. H. Von Baumhauer, then present at Buffalo, chose James Hall for its chairman and T. Sterry Hunt for its secretary. A circular in various languages was at once issued, urging the importance of the proposed congress, for the consideration of which various points were suggested, and recommending the bringing together at the exhibition of collections illustrating the geology of all countries. The assurances of coöperation received by the secretary were such that after a few months, the Geological Society of France took up the matter in connection with the international committee, and naming a local committee, of which Hébert was president and Jannettaz, secretary-general, issued July, 1877, a circular embodying the suggestions of the first committee. This was followed by a second circular, dated February, 1878, fixing the opening of the Congress for the 29th of August. The local committee also prepared a catalogue of all the materials of geological interest in the Exhibition, as well as of all the public and private collections of Paris, which were thrown open to the members of the Congress.

The Congress was opened on the day appointed in the palace of the Trocadero, the Minister of Public Instruction for France, presiding on the occasion, and six daily sessions were held, with Hébert for president, assisted by numerous vice-presidents selected from the various nationalities. The whole number of members enrolled was 328, of which about 250 were present. American geology was represented by James Hall, G. H. Cooke, J. P. Lesley, T. Sterry Hunt, W. P. Blake, E. D. Cope, and T. C. Chamberlin, and by Selwyn from Canada.

The first session was devoted to structural and dynamical geology and included among others, papers by Daubrée and Alphonse Favre, both giving results of experiments relative to the origin of

fractures and foldings of the earth's crust. These were followed by Lory on the structure of the Alps, by de Chancourtois on the coördination of the lines and veins, and by De Lapparent on the foldings of the Chalk as disclosed by the examinations for the tunnel beneath the streets of Dover.

In the second session, James Hall discussed the history of the rise and progress of the nomenclature of the Paleozoic rocks in North America, and of the various geological maps, while Renevier, de Chancourtois and Huguenin submitted their plans for the use of colors and signs in mapping. Stephanesco and Rutot discussed the value of geological subdivisions and the bases of a uniform geological nomenclature for all countries, while Vilanova set forth his plan of a general dictionary of geology.

In the third session, Sterry Hunt presented a memoir on the upper and lower limits of the Cambrian series, and was followed by Barrande on the same subject. Von Mœller then discussed the constitution of the Carboniferous series in different regions of Europe, and its relations to Devonian and Permian, and was succeeded by Lesley on the same questions as presented in Pennsylvania, and by Vélain on the relations of the Trias and Lias in France.

In the fourth session, Cope discussed the relations of the horizons of fossil verebrates in Europe and America, and was followed by Albert Gaudry and by Matheson on the same subject. De Mortillet presented his views on the Quaternary formations, and Alph. Favre discussed the hypothesis of former glacial periods. Van der Broeck and Buviguier discussed the agency of meteoric phenomena in the alterations of rocks, and W. P. Blake presented and described a geological map of the United States of America. The origin of volcanoes was then considered by Virlet d'Aoust, after which the local admixtures of organic remains of different horizons, giving rise to what have been called colonies is alike in Jurassic and Devonian strata, was discussed by Choffat, Renevier and Gosselet.

In the fifth session, DesCloizeaux and Michel Lévy discussed various questions as to the feldspars in crystalline rocks, their chemical composition and microscopic character, and were followed by Sterry Hunt, on the constitution of the plagioclase feldspar, while Jannetaz treated of the geological importance of the propagation of heat in rocks, considered with reference to their structure and their origin. Sterry Hunt then gave a description of the great groups of crystalline stratified rocks found in North America, including Laurentain, Norian, Huronian, Mount Alban and Taconian, and compared them with similar groups in Europe. He was followed by Selwyn on the same subject. Szabo discussed the eruptive Tertiary rocks of Hungary, examining the question whether mineral composition can serve to show the ages of such rocks. Velaine contributed an account of the trachytes of the Reunion island and Ribeiro and of the Tertiary basalts of Portugal.

In the sixth and last session of the Congress, on the 4th of September, a communication by Bourjot was presented on the supposed eruptive limestones of Algeria, and one on some glacial phenomena of the Great Lakes district of North America, by Chamberlin, while Fuchs stated the views of several members of the Congress on the system of coloring geological maps. The President then announced the decision of the Council that the acts of the Congress are to be published in a volume under the direction of the secretaries, the cost being generously defrayed by the national government. A second International Geological Congress will be held at Bologna in Italy, in October, 1881, under the honorary presidence of Sella, president of the Accademia dei Lincei of Rome, and a local committee of ten Italian geologists has been named, charged with the organization of the Congress, of whom Prof. Capellini of Bologna will probably act as secretary. The government of the King of Italy, through the ambassador at Paris, at once promised its high patronage to the future Congress, and the municipality of Bologna sent a message of welcome.

The work of the next congress is referred to two international committees; the first of which will be charged with the unifications "des figures géologiques," that is to say, of all colors or signs employed on geological maps and plans. The second is charged with the unification of geological nomenclature, under which will be considered all questions relating to classification, as well as the value and significance of mineralogical, lithological and paleontological characters embracing the most important problems in geology. For these two international committees one member is named for each country, whose duty it will be to organize therein local committees, and to make known the composition of these as soon as possible both to the Secretary-General of the late Congress, and to the local committee of the future one. Reports by these several committees are to be sent before the first of January, 1881, to the Italian local committee of organization, who will cause them to be printed and distributed before the meeting of the Congress.

The members of the international committee on maps are as follows: United States, Lesley; Canada, Selwyn; Great Britian, Ramsay; France, de Chancourtois; Belgium, Dupont; Switzerland, Renevier; Italy, Géordano; Spain and Portugal, Ribeiro; Hungary, von Hautken; Russia, von Mœller; Scandinavia, Torell.

The international committee on nomenclature and classification is thus composed: United States, James Hall; Canada, T. Sterry Hunt; Great Britain, T. McKenna Hughes; France, Hébert; Belgium, Dewalque; Germany, Ferd. Römer; Switzerland, Alph. Favre; Italy, Capellini; Spain and Portugal, Vilanova; Hungary, Szabo; Roumania, Stephanesco; Russia, Inostranzeff; Scandinavia, Lundgren; Australia, Liversidge.

In addition to the above a local committee was named in France to discuss for the next Congress, the rules to be observed

in the nomenclature of species, consisting, for paleontology, of Cotteau, Douvillé, Gaudry, Pomel, Gosselet and de Saporta, and for mineralogy and lithology, of DesCloizeaux and Jannettaz. The report of the committee of the American Association in 1876, on biological nomenclature, presented by Cope to the Congress, was referred to the above-named committee. The general language of the proceedings was of course, French, but communications made in English were interpreted by MM. Barrois and T. Sterry Hunt, and will be duly translated for the published acts of the Congress.

T. S. H.

2. *National Academy of Sciences.*—At the session of the National Academy of Sciences in New York City, November 5–8, 1878, the following papers were presented.

HENRY DRAPER.—The Solar Eclipse of July 29, 1878.

S. H. SCUDDER.—The early types of insects.

C. S. PEIRCE.—The acceleration of gravity at initial stations.

W. P. TROWBRIDGE.—The inapplicability of the old theory of the turbine water-wheel to the newer constructions instituted by Boyden & Francis.

A. A. AGASSIZ.—(1.) The embryology of the gar-pike.—(2.) Arrangement of a zoological marine laboratory at Newport, R. I.

ELIAS LOOMIS.—Contributions to Meteorology: the storms of the Atlantic Ocean.

H. L. ABBOTT.—(1.) Biographical memoir of Prof. D. H. Mahan.—(2.) Value of photography in the study of instantaneous phenomena, illustrated by photographs of torpedo explosions.

BENJAMIN ALVORD.—Continuation of paper presented at the April meeting, On the intersection of circles and the intersection of spheres.

STEPHEN ALEXANDER.—(1.) On the eleventh axiom of Euclid and a proposed demonstration of the same.—(2.) Recapitulation of some of the author's views on the origin of the forms and present state of many clusters of stars and of several nebulæ, the source of solar heat, and drift of the stars.—(3.) Brief notice of the total solar eclipse of January 11, 1880.—(4.) On certain modifications of the Sclehallien experiments, and of the Cavendish experiment.

GEORGE DAVIDSON.—Instruments of precision at the Paris Exposition.

J. S. NEWBERRY.—(1.) On some remains of new fossil fishes and their relation to living forms.—(2.) On some mooted points in American Geology.

O. N. ROOD.—(1.) On a quantitative analysis of white light.—(2.) Note on Henry's theory of color.

E. D. COPE.—On the characters of the Theromorphous Reptilia and Stegocephalous Batrachia.

C. A. YOUNG.—Measures of the diameter of Mercury by a new method, made at the transit of May 6, 1878.

A. HYATT.—Some remarks on an investigation on the laws of heridity undertaken by the Board of Health of Massachusetts.

At the same session on November 6, the Acting President submitted the following *Report of the Committee appointed to consider the Scientific Surveys of the Territories of the United States.* The Report was adopted by the Academy.

The Committee of the National Academy of Sciences, to whom has been referred the consideration of the following requirement of law contained in the Act making appropriations for Sundry Civil expenses of the Government for the fiscal year ending June 30, 1879, and for other purposes, approved June 20, 1878, namely:

"And the National Academy of Sciences is hereby required at their next meeting to take into consideration the methods and

expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress as soon thereafter as may be practicable a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps, and documents, and other results of the said surveys,"

Submitted the following report:

The Committee consider that the field of inquiry proposed to the Academy is intended to embrace only such surveys as pertain to the public domain. They have not included in their plan of organization surveys and investigations, however scientific in method and character, which apply solely to engineering works, such as the improvements of rivers, harbors, lakes, etc.; the irrigation and drainage of public lands, reclamation of tidal lands, and protection of alluvial regions from floods. Such surveys and investigations, being inseparably connected with engineering problems, should, in the judgment of the Committee, be conducted by the Engineer Corps of the Army. Nor do the Committee recommend any change in the organization of the Survey of the Great Lakes, as this is now nearly completed.

The works which seem to fall especially within the limits of the meaning of the law are: the Geographical Surveys west of the one hundredth meridian, under the War Department; the United States Geographical and Geological Surveys of the Territories and of the Rocky Mountain region, under the Interior Department; and the system of Land Surveys, under the supervision of the Land Office. Besides these, although not enumerated in the law, one of the most important works now in progress in the interior, under Act of Congress, is the geodetic work of the Coast and Geodetic Survey. Parties of this organization are now conducting a systematic triangulation at several points in the interior, and any general system, such as is contemplated in the above law, cannot be wisely devised without taking into account the object and organization of this survey. The objects of these various surveys are: (1.) An accurate geodetic survey. (2.) A general geographical and topographical reconnoissance. (3.) Land parcelling surveys, on which the Government can part title to portions of the public domain. (4.) The economic classification and valuation of the public domain. To these should be added, the gradual completion of a general accurate topographical map of the whole Territory of the United States, which shall serve as a basis for all the scientific and practical needs of the Government and the people. All this work may be included under two distinct and separate heads: (1.) Surveys of mensuration. (2.) Surveys of geology, and economic resources of the soil.

We will first consider the present operations of the surveys of mensuration. Such surveys are now in progress under five dif-

ferent independent organizations: that of the Coast and Geodetic Survey; of the Geographical Surveys west of the one hundredth meridian, under the War Department; of the topographical work of the two surveys under the Interior Department; and of the Land Survey under the Land Office. The final object of all these works of mensuration is the accurate determination of position, and the laying down of lines and points by measurement. There is at present no coördination between these five surveys. Their original determinations of position are independent; their systems of survey discordant; their results show many contradictions, and involve unnecessary expenditure. The geographical reconnoissances carried on under the War and Interior Departments are of little value for the parcelling of land, while the land surveys are of correspondingly slight topographical and geographical value. The operations of the Coast and Geodetic Survey in the interior do not at present include topography and land parcelling. To attain the desirable accuracy, and economy, it is absolutely essential that there should be only one geodetic system, one topographical system, and one land parcelling system, all conducted under the same head. It is evident that both topographical and land parcelling surveys, to be properly coördinated and sufficiently exact, must be based upon a single rigid geodetic foundation. All these three divisions are departments of measuring; all are based upon accurate determinations of position; and, to be effectively and economically carried out, should be united into one comprehensive system.

After a careful consideration of the facilities at the disposal of the several existing organizations engaged in this work, the Committee believe that the Coast and Geodetic Survey is practically best prepared to execute the entire mensuration system required. Within the public domain, the dominant interest of the United States is centered in the public lands which remain to be surveyed and sold. The administration of these lands, consisting of 1,101,107,183 acres, is necessarily within the Department of the Interior, while the Coast and Geodetic Survey, having been originally inaugurated to meet the wants of commerce, has been hitherto under the Treasury Department. In view of the paramount importance of the public lands, the Committee recommend that the Coast and Geodetic Survey be transferred from the Treasury Department to the Department of the Interior, retaining its original field of operations, and assuming, also, the entire mensuration of the public domain; and that, so modified and extended, it hereafter be known as the United States Coast and Interior Survey. This organization would then embrace, in addition to its former work, a geodetic survey of the whole public domain, a topographical survey comprising detailed topographical work and rapid reconnoissance, and land parcelling surveys.

The Superintendent of the Coast and Interior Survey should be appointed by the President, and should report directly to the Secretary of the Interior.

The best interests of the public domain require for the purposes of intelligent administration a thorough knowledge of its geological structure, natural resources, and products. The domain embraces a vast mineral wealth in its soils, metals, salines, stones, clays, etc. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The Committee, therefore, recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economic resources of the public domain; such survey to be placed under a Director, who shall be appointed by the President, and who shall report directly to the Secretary of the Interior.

It should be specially provided that the Director and members of the Geological Survey, charged as they are with the investigation of the natural resources of the public domain, shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations.

Officers of the Army and Navy, when not otherwise employed, might be detailed by the Secretary of War or of the Navy to take part in the operations of either survey.

With the inauguration of the two surveys above defined, the Committee recommend a discontinuance (1) of the present Geographical and Geological Surveys west of the one hundredth meridian, under the War Department, except surveys necessary for military purposes and local internal improvements; (2) of the Geographical and Geological surveys now in progress under the Department of the Interior; and (3) the present Land surveys under the Land Office.

The effect of the above changes will be to maintain within the Interior Department three distinct organizations; (1) the Coast and Interior Survey, whose function will embrace all questions of position and mensuration; (2) the United States Geological Survey, whose function will be the determination of all questions relating to the geological structure and natural resources of the public domain; (3) the Land Office, controlling the disposition and sale of the public lands, including all questions of title and record. With this division should be secured a perfect coördination and coöperation between the three branches. The Land Office should call upon the Coast and Interior Survey for all surveys and measurements required for the sale and disposition of land. The Land Office should also call upon the United States Geological Survey for all information as to the value and classification of lands. The results of all the mensuration surveys, as soon as completed, should be immediately available for the Land Office, and for the Geological Survey, and for other branches of the Government as required. The Geological Survey should be

authorized to execute local topographical surveys for special purposes, such, for instance, as the subterraneous surveys of mining districts and metallic deposits, etc.

Each of the three organizations, thus defined, should make an annual report of its operations to the Secretary of the Interior. The publications of the Land Office should embrace reports of its business operations relating to the disposition and sale of land, together with the necessary maps. The publications of the Coast and Interior Survey, besides the annual report of operations, should consist of its geodetic results, geographical, topographical and cadastral maps, coast charts, and such discussions and treatises connected therewith as the Superintendent shall deem of value. The publications of the Geological Survey should consist of an annual report of operations, geological and economic maps illustrating the resources and classification of the land, reports upon general and economical geology in all its branches, with the necessarily connected paleontology.

All collections made by the Coast and Interior, and the Geological Surveys, when no longer needed for the investigations in progress, should be transferred to the National Museum.

The Committee recommend that, upon the organization of the United States Coast and Interior Survey and the United States Geological Survey, a commission be formed, to consist of the Commissioner of the Land Office, Superintendent of the Coast and Interior Survey, Director of the United States Geological Survey, the Chief of Engineers of the Army, and three other persons to be appointed by the President, who shall take into consideration the codification of the present laws relating to the survey and disposition of the public domain; and who shall report to Congress within one year a standard of classification and valuation of the public land, together with a system of land parcelling survey. The necessity of this commission is evident from the fact that by far the larger part of the public domain lies in the region where, from geological and climatic causes, the lands are for the most part not valuable for field-culture; and where the system of homestead preëmption and sale in accordance with existing laws is both impracticable and undesirable.

In regard to publications of the two surveys above defined, the Committee recommend that, besides the number of copies of each report which Congress may order for its own distribution, three thousand copies be published, for scientific exchanges by the heads of these surveys, and for sale at the price of publication; that all literary and cartographic material received by the heads of these surveys in exchange be the property of the United States, and form a part of the libraries of the two organizations; that the money resulting from the sale of these publications be covered into the Treasury. The Committee recommend that the annual reports of operations of the two surveys accompany the report of the Secretary of the Interior; that the special memoirs and reports of both surveys be issued in uniform quarto series; that the style

and scale of the cartographic publications be determined by the head of each organization, so as to express the scientific results in the most effective and economical manner.

All of which is respectfully submitted:

O. C. MARSH, *Vice President, and Acting President.*

JAMES D. DANA, WILLIAM B. ROGERS, J. S. NEWBERRY, W. P. TROWBRIDGE, SIMON NEWCOMB, ALEX. AGASSIZ, *Members of the Committee.*

[This Report was submitted to Congress at the opening of the present session and referred to the Committee on Appropriations.]

3. *New York Academy of Sciences.*—Nos. 1 to 4 of the Annals of the New York Academy of Sciences (late Lyceum of Natural History), extending to 128 pages, 8vo, have been published. They contain papers by H. C. Bolton, on the application of organic acids to the examination of minerals; on prehistoric Bronze bells from Japan, by H. S. Munroe; on the variations in Lepidodendron and Sigillaria, by H. L. Fairchild; on new species of Birds, by G. N. Lawrence; on the literature of titanium, by E. J. Hallock; on new fossils of the Upper Silurian of Port Jervis, by S. F. Barrett; on new fossil fishes of the Trias, by J. S. Newberry; and they are illustrated by nine plates, six of them by H. L. Fairchild. Dr. Newberry describes *Diplurus longicaudatus*, from Boonton, N. J., and *Ptycholepis Marshii*, from Durham, Conn.

4. *Anales de la Oficina Meteorologica Argentina;* por su Director, B. A. GOULD. Tome 1. Clima de Buenos Ayres. 4to, pp. 523, and 17 plates. Buenos Ayres, 1878.—This first volume of Annals of the Meteorological Bureau of the Argentine Republic contains the first four annual reports of the Director. Following these are tables exhibiting the peculiarities of the climate of the city of Buenos Ayres. The materials for this discussion are quite full records of meteorological observations since 1856, and less complete ones during scattered years from 1801 to 1856. The principal part of the computations were made by Dr. Gutermann. The results are very fully exhibited in the plates. In the future volumes of the Annals, Dr. Gould expects to give the observations made at numerous other points in the Republic, with discussions of them.

5. *Science News.*—A new scientific periodical, under the editorship of Ernest Ingersoll and W. C. Wyckoff, and published fortnightly by S. E. Cassino, at Salem, Mass. Each number is to contain at least sixteen pages octavo of reading matter, and its peculiar feature is stated to be "the prompt publication of scientific news." No. 1 (November 1st), contains short articles by Dr. C. C. Abbott, Professor F. W. Clarke, Dr. Elliott Coues and others; Nos. 2 and 3 are chiefly occupied with abstracts of papers read at the recent meeting of the National Academy of Sciences.

6. *An American Geological Railway Guide, giving the geological formation at every railway station, with notes on interesting places on the routes, and a description of each of the formations;* by JAMES MACFARLANE, Ph.D. 216 pp. 8vo. New York,

1879. (D. Appleton & Co.)—The scope and general object of this work are well stated in the above title. It occupies a decidedly new place among handbooks of travel and contains a great amount of information in a very condensed form.

7. *Essentials of Chemistry, Inorganic and Organic, for the use of Students in Medicine;* by R. A. WITTHAUS. New York, 1879. 18mo, pp. 257. (William Wood & Co.)—The author has skillfully condensed the "Essentials of Chemistry," for the Medical student, into a vest-pocket catechism, which fulfills well the object for which his little volume has been prepared.

8. *Handbook of Alabama:* A complete index to the State; with a geological map and an Appendix of useful tables, by SAFFOLD BERNEY.—This volume contains a valuable outline of the geology of Alabama, with a geological map of the State, by Eugene A. Smith, Ph.D., State Geologist.

The Amateur's Handbook of practical Information for the Workshop and the Laboratory: containing directions for bronzing, lacquering, polishing metal, etc. 44 pp. 12mo. New York, 1878. (The Industrial Publication Company).

On the Structure of the Stylasteridæ. A family of Hydroid Stony Corals, by H. N. Moseley, F.R.S., late Naturalist on board H. M. S. Challenger. (From the Philosophical Transactions of the Royal Society, Part II, 1878.

Annual Report of the Chief Signal Officer to the Secretary of War for the year 1877. 570 pp. 8vo, with 34 maps and 18 charts. Washington, 1877.

Description of eight new species of Holocystites from the Niagara Group, by S. A. Miller. The new species are: *H. Brauni, H. Wetherbyi, H. ornatus, H. perlongus, H. globosus, H. pustulosus, H. plenus, H. elegans;* they are from Jefferson and Ripley counties, Indiana.

Remarks on some Lamellibranchiate Shells of the Hudson River Group by R. P. Whitfield. The new species are: *Cypricardites quadrangularis, Cuneamya curta, Orthodesma Mickleboroughi, Sedgwickia (?) lunulata;* locality, Clinton Co., Ohio.

A Handbook of the Electric Telegraph, by A. E. Loring. 98 pp. 12mo. New York, 1878 (Van Nostrand's Science Series).

Statistical Sketch of South Australia, by Josiah Boothby. 86 pp. 8vo. London, 1876. Published by authority of the Government. (Sampson Low, Marston, Searle, & Rivington, London.)

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Report on the Meteorological Service of the Dominion of Canada, by the Superintendent; to which is appended the Report of the Directors of the Magnetic and other Observatories, for the year ending December 31st, 1877. Ottawa, 1879.

APPENDIX.

ART. IX.—*A new Order of Extinct Reptiles* (SAURANODONTA), *from the Jurassic Formation of the Rocky Mountains;* by Professor O. C. MARSH.

THE absence of the genus *Ichthyosaurus* in the extinct fauna of this country has long been a noteworthy feature, for up to the present time no traces of it have been detected, although its remains are especially abundant in Europe. An interesting specimen recently discovered in the Rocky Mountain region presents, in most of its skeleton, the characteristics of that genus, but is *without teeth*. The vertebræ, ribs, and other portions of the skeleton preserved, cannot be distinguished from the corresponding parts of *Ichthyosaurus*, and many features of the skull show a strong resemblance. The general form of the skull is the same. The great development of the premaxillaries; the reduced maxillaries; the huge orbit defended by a ring of bony plates, are all present, but the jaws appear entirely edentulous, and destitute even of a dentary groove.

The proportions of this reptile were very similar to those of *Ichthyosaurus*. The skull is about two feet (600^{mm}) in length, and the facial portion especially produced. The orbits are very large, and the space between them is 140^{mm}. The sclerotic ring is composed of only eight plates. Its diameter at the base is 106^{mm}, and at the apex 58^{mm}. These plates are not arranged in a nearly flat ring, as in *Ichthyosaurus*, but form the basal segment of an elongated cone, as in the eyes of some birds. The vertebræ are short, and deeply bi-concave. The neural arch is articulated to the centrum. One trunk vertebra measures 85^{mm} in width, 38^{mm} in length on the floor of the neural canal, and 21^{mm} between the centers of the two rib articular faces of the same side. The length of the entire animal was about eight or nine feet. The remains at present known are all in the Museum of Yale College.

This reptile may be called *Sauranodon natans*, and the order it represents *Sauranodonta*. This genus bears a similar relation to the Ichthyosaurs that *Pteranodon* does to the true Pterodactyls, and it is interesting to find the two highly specialized forms preserved in the same region.

The geological horizon of the *Sauranodontidæ*, so far as now known, is in the Jurassic, immediately below the Atlantosaurus beds. The accompanying fossils are Ammonites and Belemnites, showing more distinctly marine deposits, which may be called the Sauranodon beds.

Yale College, New Haven, December 27, 1878.

ART. X.—*Principal Characters of American Jurassic Dinosaurs;* by Professor O. C. MARSH. Part II. With eight Plates.

IN a previous article (vol. xvi, p. 411, Nov., 1878), the writer gave a short account of the geological horizon and accompanying fossils of the Jurassic Dinosaurs recently found in the Rocky Mountains; and also stated the more important characters of the gigantic *Sauropoda*, as illustrated mainly by the genus *Morosaurus*. In the present communication, this group is further elucidated by a comparison of the structure in some other American genera, especially *Apatosaurus* and *Atlantosaurus*, to which belong the largest reptiles hitherto discovered. The carnivorous enemies of this group are also briefly described. The pelvis of Dinosaurians, hitherto so little known, is illustrated by new examples, and by the corresponding parts in some recent birds.

Apatosaurus Marsh, 1877.*

The genus *Apatosaurus* may be readily distinguished from *Morosaurus* by the sacrum, which consists of only three vertebræ instead of four (Plates V and VI, figures 1 and 2.) The ischium, also, has its distal end expanded. The scapula, likewise, is quite different, its superior extremity, being without the anterior extension seen in *Morosaurus* (Plate IV.) So far as at present known, the latter character, together with the form of the sacrum, separates it from the allied genus *Atlantosaurus*.

The cervical vertebræ of *Apatosaurus* are strongly opisthocœlian, and of moderate length. (Plate III, figures 1 and 2.) The dorsals have their centra similar, and both have deep cavities in the sides and in the neural arch resembling those in the corresponding vertebræ of *Morosaurus*. The lumbar vertebræ have their articular faces more nearly plane, and the last lumbar

* This Journal, vol. xiv, p. 514.

is expanded transversely. The sacrum is characteristic of the genus, and quite unlike any hitherto known. The type specimen on which the genus was established is well shown in Plate VI, figure 1. It is short and massive, and the three vertebræ which form it are nearly equal in size and general proportions. They are firmly coössified, and their transverse processes are ankylosed to the centra. Those on each side are united distally into a solid mass, which rests on the short ilium. The articular faces of the sacral vertebræ are nearly plane. That of the anterior centrum is a transverse oval in outline, and the posterior face is more nearly round. The centra and their processes are somewhat lightened by cavities, as in the sacra of *Atlantosaurus* and *Morosaurus*. The sacrum of the latter genus, shown in figure 2 of Plate V, is built upon the same general plan, characteristic of the *Sauropoda*, but the transverse processes are less massive, and have a greater vertical elevation. The same sacrum is shown in position in Plate V, figure 1. A striking feature of this sacrum is seen in the large size of the neural canal (*nc*), which, strange to say, is here two or three times the diameter of the brain cavity. This is a most suggestive fact, and without parallel in known vertebrates.

The scapula of *Apatosaurus* is large (Plate IV), and has in its lower portion an anterior projection similar to that in *Morosaurus*.* Above this, the shaft continues about the same width to the upper end, which is comparatively thin. The coracoid is small in proportion to the scapula, and subquadrate in outline, thus differing in form from that of *Morosaurus*. The foramen is large, and near the superior border.

There is at present some difficulty in separating the limb bones and various other parts of the skeleton of *Apatosaurus* from the corresponding portions of *Atlantosaurus*, especially as the type species of each are nearly equal in size, and their remains are found in the same localities. The sacra show the genera to be quite distinct, and the abundant material now in the Yale Museum, when carefully collated, will enable other parts of the structure to be compared. The teeth in all the herbivorous genera of the *Sauropoda* from the Atlantosaurus beds, so far as now known, appear to be very similar, and hence do not afford generic characters.

The type species of the present genus is *Apatosaurus ajax* Marsh, and the known remains indicate a reptile at least fifty feet in length. A much larger species is indicated by various remains from the same locality in Colorado, among which is the huge cervical vertebra represented in Plate III, figures 1 and 2. This species had a short massive neck, and hence may be

* This Journal, vol. xvi, Plate VI.

called *Apatosaurus laticollis*. The size of the entire animal may be judged from this vertebra, which measures over three and a half feet (1·07 M) in width. This would imply a neck at this point not less than five or six feet wide,—a marked contrast to the long and slender neck of *Morosaurus grandis*, a vertebra of which is figured in the same plate for comparison. All the cervical vertebræ of the present species now known are unusually short, and the neural spine is rudimentary or wanting. With the exception of the articular faces of the centra, the resemblance of these cervicals to those in some birds is very striking.

The limb bones at present referred to this species have a general resemblance to those of *Morosaurus*, described by the writer in the previous article. The pelvic bones appear to be more like those of *Atlantosaurus*.

The more important remains of this genus now known were found in the Upper Jurassic of Colorado, by Mr. Arthur Lakes, of the Yale Museum, to whom science is indebted for other interesting discoveries.

Atlantosaurus Marsh, 1877.*

The typical species of this genus is *Atlantosaurus montanus*, and the type specimen on which it was based is represented by the sacrum figured in Plate VI, and various fragmentary remains found with it, and pertaining to the same individual. This sacrum resembles that of *Morosaurus* (Plate V, figure 2), in having four vertebræ, but a comparison of the two shows many differences. The centra of the second and third vertebræ are deeply excavated below on each side, leaving a comparatively narrow keel on the median line. From each opening between the transverse processes, a large cavity extends inward and backward into the centra, greatly lessening the weight of the sacrum. These important characters were mentioned in the original description, (vol. xiv, p. 87, July, 1877), in which the discovery of these large reptiles was first announced.

The ilium in *Atlantosaurus* is comparatively short and massive, but its exact outline has not been fully determined. Its articulations resemble those in the ilium of *Morosaurus*, and in the pelvis represented in Plate VII, figure 2, the outline of this bone is restored from that genus. The pubis is somewhat like that in *Morosaurus*, and its position in the pelvis very similar. It has three distinct articular faces on its proximal end, and, below the ischiadic union, a post pubic projection indicated in the diagram by *p'*. The distal end is expanded, and rugose for union with its fellow on the median line, as shown in the pelvic

* This Journal, vol. xiv, p. 514. Also p. 87.

arch of *Morosaurus*, in Plate V, figure 1. The ischium is less massive than the pubis, and it is directed downward, backward and inward. The acetabular face is larger than that of the pubis. The shaft of the ischium is not curved as in *Morosaurus*, and the distal end is widely expanded, and unites with its fellow on the median line, in a strong symphysis. The difference in the pelves of the two genera are well shown by a comparison of the figures in Plate VII. The ischium of *Morosaurus* is somewhat more twisted in its distal half than the artist has drawn it in figure 1, where the three bones are represented nearly in the same plane.

The vertebræ referred to *Atlantosaurus* are opisthocœlian in the cervical region, and the caudals preserved resemble those in *Morosaurus*. The limb bones, so far as known, are similar in their more important characters to those in that genus.

The two species now placed in the genus *Atlantosaurus* are the type, *A. montanus*, and *A. immanis*, which contain the largest land animals yet discovered. The latter species may possibly belong to the genus *Apatosaurus*.

The genera of *Sauropoda* above described and figured, viz: *Morosaurus*, *Diplodocus*, *Apatosaurus* and *Atlantosaurus*, show this suborder to be a well marked and natural group, the most generalized of the Dinosaurs. Some other generic names have been given to members of this group by Cope, which I shall review at another time. He still places the horizon of these reptiles in the Cretaceous, although the evidence of their Jurassic age seems now conclusive. In one species which he calls *Camarasaurus supremus* (identical according to Professor Owen with his genus *Chondrosteosaurus* from the English Wealden),† he says, in the sacrum, "the centra are like those of the caudal vertebræ composed of dense bone,"‡ a statement wholly discordant with the known characters of the group. He likewise describes the diplosphenal articulation of the vertebræ as unknown, and states (page 76) that it "has not been observed in any other animals;" whereas it has long been known in *Megalosaurus*, one of the earliest Dinosaurs described, as well as in other genera. The pelvic bones of this species, he says, do not resemble those of *Dinosauria*, when, on the contrary, the pubis he figures is typical in the group. Conclusions based on such work will naturally be received with distrust by anatomists.

Allosauridæ.

In addition to the huge *Sauropoda*, and the small species of the genus *Laosaurus*, described in the previous article, numerous

† Annals and Mag. Nat. Hist., vol. ii, p. 201, Sept., 1878.
‡ Am. Naturalist, vol. xii, p. 77.

remains of carnivorous Dinosaurs occur in the same beds, and indicate the natural enemies which kept in check their herbivorous cotemporaries. These carnivorous forms represent two very distinct families; the *Allosauridæ*, resembling in many respects *Megalosaurus* and its near allies; and the *Nanosauridæ*, a widely different group, which appears to have some affinities with *Compsognathus*. In the present article, the former group is briefly discussed, and both will be more fully described in a future communication.

The genus *Allosaurus* is typical of the family, which also includes *Creosaurus*, and *Labrosaurus*. The first named genus presents some very interesting features in the vertebræ, and pelvic arch. The vertebræ first described are remarkable for the reduction of the centrum by constriction, so that the requisite lightness is secured without cavities in the interior. This is shown in the lumbar vertebra represented in Plate X, figures 3 and 4. The diplosphenal articulation of the zyapophyses, seen in the corresponding vertebræ of *Megalosaurus*, and in some other Dinosaurs, is well marked in these vertebræ.

The sacrum in *Allosaurus* apparently contains four vertebræ only, and these have very short and stout transverse processes, not united at their distal ends. These processes are coössified with the sides of the centra, and their extremities are obliquely truncated for union with the ilia, which thus stand nearly vertical, or somewhat divergent above. The exact form of the ilium is not known with certainty, and in the diagram given in Plate VIII, figure 2, the outline is taken from the ilium of *Creosaurus*. The pubis is perhaps the most remarkable bone in the skeleton, and its determination and position solve many difficulties in the structure of the Dinosaurian pelvis, especially in the Carnivorous types. At its proximal end, this bone has four well-marked articular faces; one in front for the ilium; next the acetabular face; an oblique face for the ischium; and below this another, of about equal size, to which a separate bone was apparently articulated. Judging from the structure of the pelvis in *Laosaurus*, this bone should be the postpubis, and it is so indicated in the figure (Plate VIII, figure 2, p'). The shaft of the pubis is slender, and the distal end is expanded longitudinally, and firmly coössified with its fellow. The two seen from the front resemble an acute letter V. This type of pubic bone has long been a puzzle to anatomists, and portions of it have been referred to various parts of the skeleton. The ischia, also, are closely united on the middle line throughout the distal half, but are not ankylosed. This makes the entire pelvic arch a remarkably narrow one.

The large bones in *Allosaurus* are hollow, and the metatarsals slender. The terminal phalanges were armed with sharp claws. With the remains described above, a large spine was found, similar in general form to that of *Omosaurus armatus* described by Owen.

The type of *Allosaurus* is *A. fragilis*,* the remains of which indicate a reptile probably twenty-five feet in length, and of slender proportions.

The genus *Creosaurus* appears to be most nearly related in its vertebræ and ilium to *Megalosaurus*. It has apparently one less vertebra in its sacrum, and the ilium has in front of its pubic process an articular face which has not been observed in the latter genus. The position of this surface is indicated in Plate X, figure 1, *f*, and it may have supported a prepubic bone. The sacral vertebræ are elongated, and the transverse processes are placed higher up on the centra than those in *Allosaurus*. The teeth in both genera are of the *Megalosaurus* type, and in the whole group are so similar as to be of little value for the determination of species. The type of *Creosaurus*, is *C. atrox*,† a reptile about twenty feet in length.

A third genus of carnivorous Dinosaurs contains individuals of somewhat smaller size, and of this group the species named *Allosaurus lucaris*‡ is the type. The cervical vertebræ are short and strongly opisthocœlian, and the dorsals moderately so. All these vertebræ have very large cavities in the centra, which connect with the exterior by a comparatively small foramen on each side. The neural spines of the dorsal vertebræ are elevated and transverse, and the vertebræ now known do not show the diplosphenal articulation. The fore limbs in this genus are quite small, and the humerus is curved, and has a large radial crest. This genus is distinct fron *Allosaurus*, and may be called *Labrosaurus*, the type being *Labrosaurus lucaris*.

All of the carnivorous Dinosaurs known from the Atlantosaurus beds appear to have moved mainly on the posterior limbs. The large bones were hollow, and many of the vertebræ, as well as some of the feet bones, contained cavities, or were otherwise lightened to facilitate rapid movement.

The reptilian remains described in these two communications are preserved in the Museum of Yale College. In addition to these fossils, the collection contains a large quantity of similar specimens, from the same localities and horizon, some of which pertain to the same skeletons as those here illustrated. The careful investigation of this entire series will require much time, but promises important results.

* This Journal, vol. xiv, p. 515. † Ibid., vol. xv, p. 243.
‡ Ibid., vol. xv, p. 242.

The descriptions and illustrations given in this and the preceding article make clear the general structure of the Dinosaurian pelvic arch, which has so long been in doubt. In the *Sauropoda*, the elements of this arch are seen united in forms that admit of direct comparison with other more typical reptiles, each genus of the group having its own special features. In the smaller, more specialized, herbivorous forms, exemplified by *Laosaurus*, an advance is seen, especially in the pubic elements, where the long rod-like avian bone is fully developed, and the anterior part, or true reptilian pubis, is still prominent. In the Carnivorous forms represented by *Allosaurus*, a more complicated structure is seen to exist, but additional material will be necessary to elucidate it fully. In the pelves of the recent birds, given in Plate IX, the remnant of the reptilian pubis is still plainly to be seen, especially in *Geococcyx*. It is not improbable that the retention of this process may be due in part to the habits of certain species, as it seems to be best developed in running birds, and those that especially use the posterior limbs. The same process, apparently, is seen in some mammals, where it may serve a similar purpose. The ilium and ischium undergo but comparatively little change from the *Sauropoda* to recent birds. The sacrum, however, is gradually strengthened by the addition of vertebræ, and their more perfect coössification.

Yale College, New Haven, December 27, 1878.

[To be continued.]

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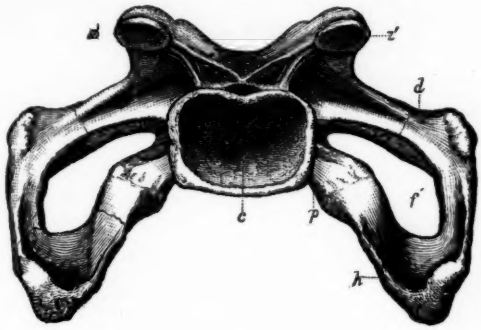

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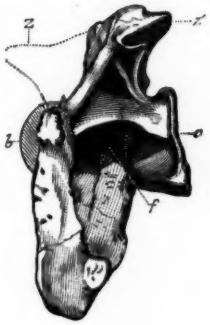

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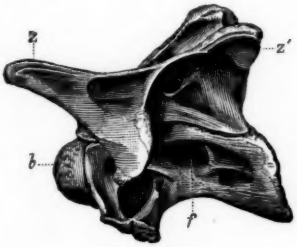

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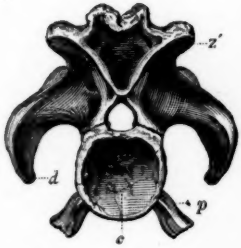
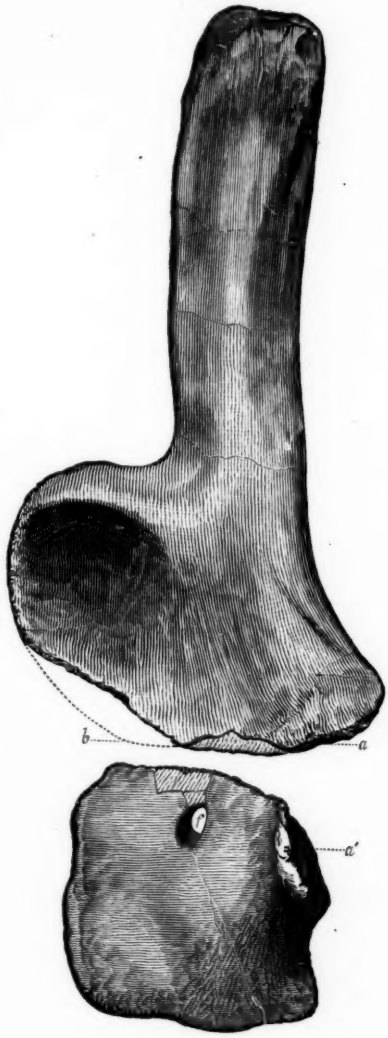


Figure 1.—Cervical vertebra of *Apatosaurus laticollis* Marsh; back view.
Figure 2.—The same; side view. Both one-sixteenth natural size.
Figure 3.—Fourth cervical vertebra of *Morosaurus grandis* Marsh; side view, one-eighth natural size.
Figure 4.—The same; back view.
The signification of the letters is the same in all the figures, viz: *b.* ball; *c.* cup; *d.* diapophysis; *p.* parapophysis; *h.* hatchet bone; *f.* foramen in centrum; *f'.* lateral foramen; *z.* anterior zygapophysis; *z'.* posterior zygapophysis.



Left scapula and coracoid of *Apatosaurus ajax* Marsh; one-fourteenth natural size. *a.* scapular face of glenoid cavity; *b.* rugose surface for union with coracoid; *a'* coracoidean part of glenoid cavity; *f.* foramen in coracoid.

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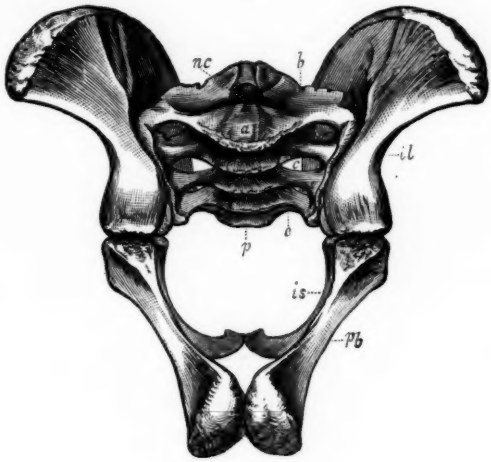

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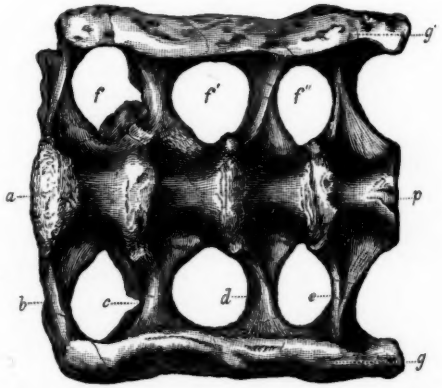

Figure 1.—Pelvic arch of *Morosaurus grandis* Marsh; seen from in front. One-sixteenth natural size.

Figure 2.—Sacrum of *Morosaurus grandis;* seen from below. One-tenth natural size.

a. first sacral vertebra; *b.* transverse process of first sacral vertebra; *c.* transverse process of second vertebra; *d.* transverse process of third vertebra; *e.* transverse process of last sacral vertebra; *f.* foramen between processes of first and second vertebra; *f'.* foramen between second and third processes; *f''.* foramen between third and last process; *g.* surface for union with right ilium; *g'.* same for left ilium; *p.* fourth, or last, sacral vertebra: *nc.* neural canal; *il.* ilium; *is.* ischium; *pb.* pubis.

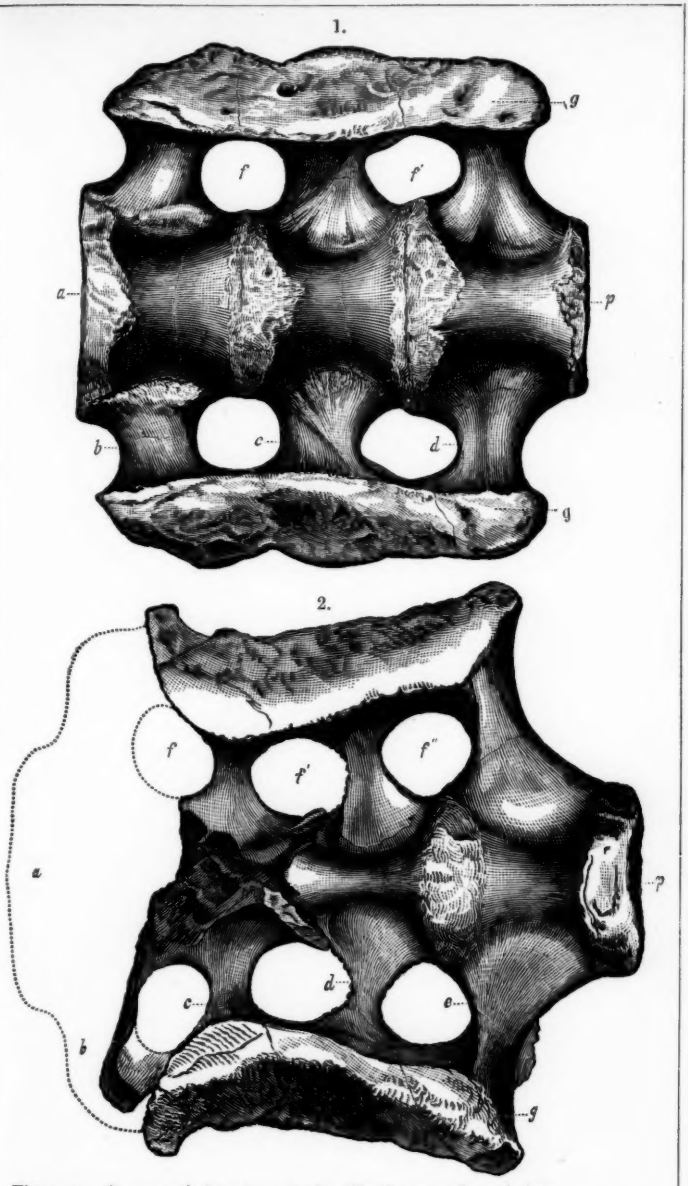

Figure 1.—Sacrum of *Apatosaurus ajax* Marsh; seen from below.
Figure 2.—Sacrum of *Atlantosaurus montanus* Marsh; seen from below; both one-tenth natural size.
a. first sacral vertebra; *b.* transverse process of first vertebra; *c.* transverse processes of second vertebra; *d.* transverse process of third vertebra; *f.* foramen between first and second transverse processes; *f'.* foramen between second and third processes; *p.* last sacral vertebra; *g.* surface for union with ilium.

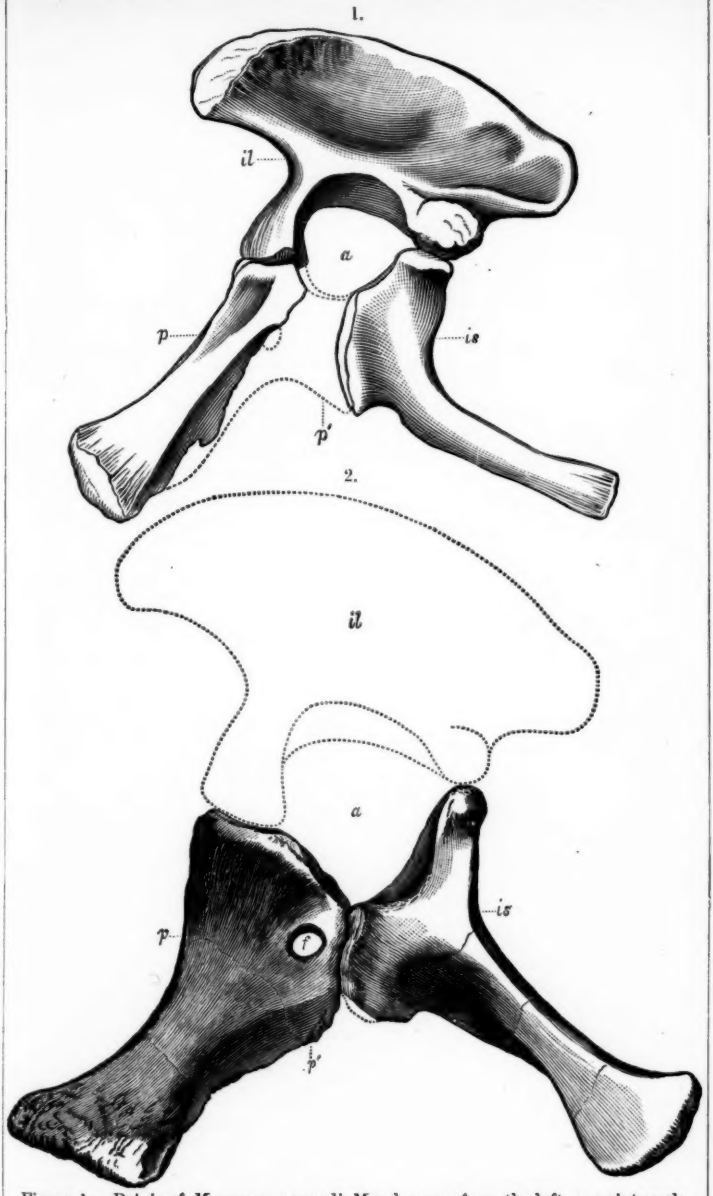

Figure 1.—Pelvis of *Morosaurus grandis* Marsh; seen from the left, one-sixteenth natural size.

Figure 2.—Pelvis of *Allantosaurus immanis* Marsh; seen from the left, one-twentieth natural size. The signification of the letters is the same in both figures, viz: *a.* acetabulum; *f.* foramen in pubis; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis. In these and the following diagrams of Dinosaurian pelves, the three bones of each are represented nearly in the same plane.

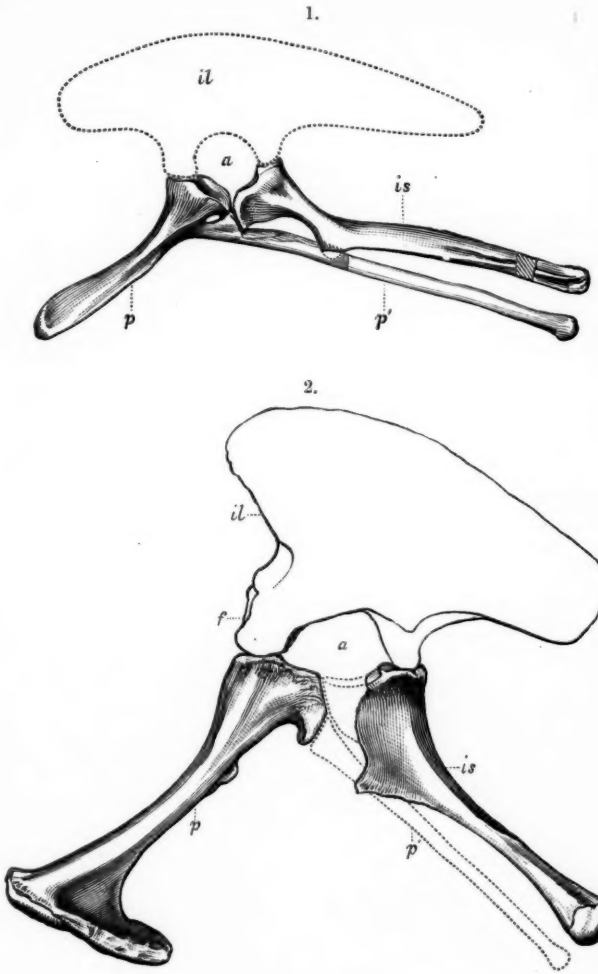

Figure 1.—Pelvis of *Laosaurus altus* Marsh; seen from the left, one-sixth natural size.

Figure 2.—Pelvis of *Allosaurus fragilis* Marsh; seen from the left, one-twelfth natural size. The outline of the ilium is taken from *Creosaurus atrox* Marsh.

The signification of the letters is the same in both figures, viz: *a.* acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis; *f.* articular facet on front of pubic process of ilium.

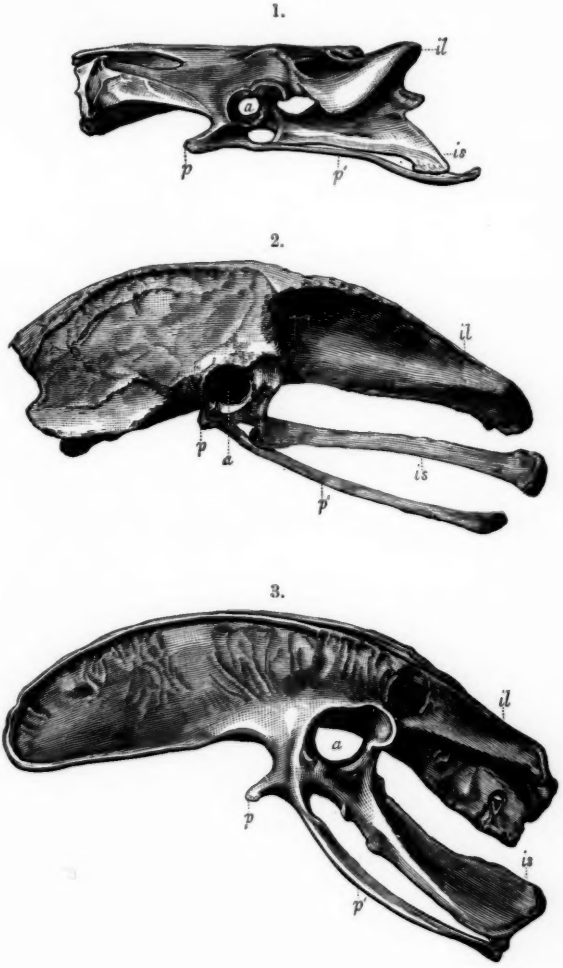

Figure 1.—Pelvis of *Geococcyx Californianus* Baird; seen from the left, natural size.

Figure 2.—Pelvis of Emeu, *Dromaius novæ hollandiæ* Lath; one-fifth natural size.

Figure 3.—Pelvis of *Apteryx australis* Owen; three-fourths natural size.

a. acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis.

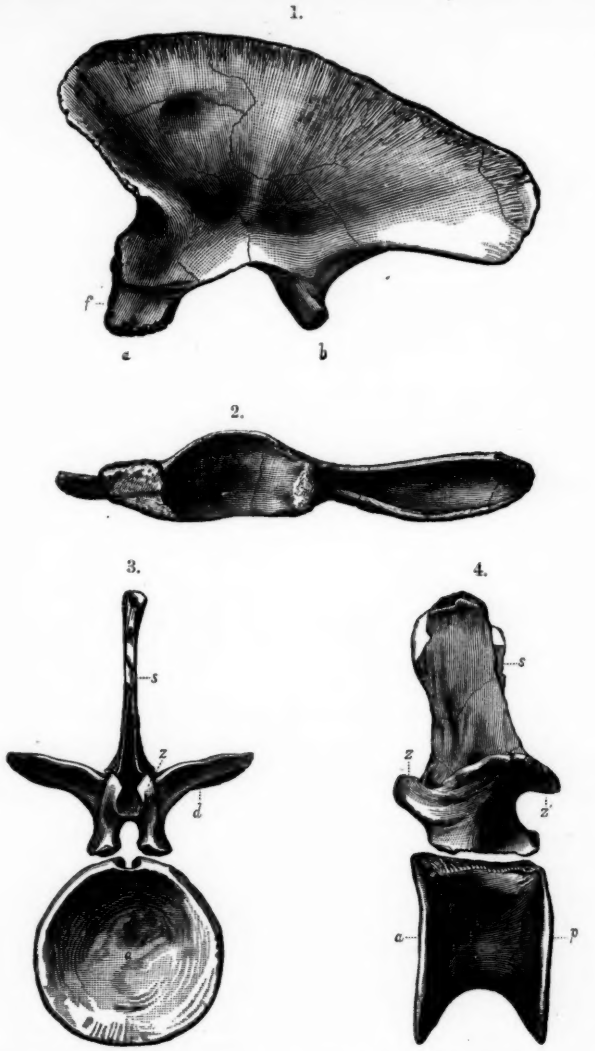

Figure 1.—Left ilium of *Creosaurus atrox* Marsh; seen from the left.
Figure 2.—The same; seen from below. Both one-tenth natural size.
a. anterior, or pubic, articulation; *b.* posterior, or ischiadic, articulation; *f.* articular facet on front of pubic process.
Figure 3.—Lumbar vertebra of *Allosaurus fragilis* Marsh; front view.
Figure 4.—The same; side view, from the left. Both one-sixth natural size.
a. anterior articular face; *p.* posterior articular face; *s.* neural spine; *d.* diapophysis; *z.* anterior zygapophysis; *z'.* posterior zygapophysis.